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GEOLOGY OF THE LATE PRECAMBRIAN FURY AND HECLA GROUP, NORTHWEST BAFFIN ISLAND, DISTRICT OF FRANKLIN

F.W. Chandler

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Critical Reader

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Preface

The Fury and Hecla Group is named after **HMS Fury** and **HMS Hecla**, ships used by Sir Edward Parry during his second attempt, in 1821-23, to find the Northwest Passage. Members of his crew were the first to report the existence of sandstones overlying crystalline basement on Baffin Island on the north shore of Fury and Hecla Strait. Nearly 100 years passed before knowledge of the extent of these rocks was improved by members of the Fifth Thule Expedition, in 1921-24. During the 1950s R.G. Blackadar of the Geological Survey of Canada carried out reconnaissance studies of these strata and of correlative rocks, now included in the Bylot Supergroup, 200 km to the north.

Although carbonates of the Bylot Supergroup host economic zinc and lead at Nanisivik Mine, the sandstone-dominated Fury and Hecla Group and its basement appear to contain only showings of uranium. Stimulated by the discovery of uranium Dr. Chandler led a multidisciplinary field party to study the Fury and Hecla Group and nearby basement rocks in summer 1979. Petrological studies of the basement rocks and geochemical and geophysical work on the uranium mineralization have been reported in other publications of the Geological Survey of Canada. This bulletin emphasizes the stratigraphy and sedimentology of the Fury and Hecla Group.

R.A. Price
Assistant Deputy Minister
Geological Survey of Canada

Préface

Le groupe de Fury et Hecla a été nommé d'après le **HMS Fury** et le **HMS Hecla**, deux navires utilisés par sir Edward Parry en 1821-1823, lorsqu'il tenta pour la deuxième fois de découvrir le passage du nord-ouest. Les membres de son équipage furent les premiers à signaler l'existence de grès sous-jacents à un socle cristallin dans l'île Baffin, sur la rive nord du détroit de Fury et Hecla. Cent ans plus tard, en 1921-1924, l'équipe de la cinquième expédition Thulé obtint d'autres données sur l'étendue de ces roches. Au cours des années 1950, R.G. Blackadar de la Commission géologique du Canada entreprit des études de reconnaissance de ces couches et des roches corrélatives trouvées à 200 km au nord, qui font maintenant partie du supergroupe de Bylot.

Bien que les roches carbonatées du supergroupe de Bylot renferment des gisements rentables de zinc et de plomb à la mine Nanisivik, le groupe de Fury et Hecla, composé surtout de grès, et son socle cristallin ne contiennent que des traces d'uranium. Encouragé par cette découverte d'uranium, M. Chandler a dirigé une équipe pluridisciplinaire chargée d'étudier le groupe de Fury et Hecla et le socle rocheux voisin, au cours de l'été de 1979. Les résultats d'études pétrologiques du socle rocheux et de l'étude géochimique et géophysique de la minéralisation en uranium ont été signalés dans d'autres publications de la Commission géologique du Canada. Le présent bulletin porte sur la stratigraphie et la sédimentologie du groupe de Fury et Hecla.

R.A. Price, sous-ministre adjoint
Commission géologique du Canada

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GEOLOGY OF THE LATE PRECAMBRIAN FURY AND HECLA GROUP, NORTHWEST BAFFIN ISLAND, DISTRICT OF FRANKLIN

Abstract

The gently inclined, unmetamorphosed, miogeoclinal, Fury and Hecla Group consists of 6000 m of quartz arenite and minor shale and dolomite. Mafic volcanics and intrusives give Neohelikian to Hadrynian K-Ar whole-rock ages. The group is correlated with the lower part of the Bylot Supergroup, 200 km north. As with the Bylot, mainly shallow marine deposition is indicated, with ocean to the west or northwest. The alluvial, basal, 500 m thick, Nyeboe Formation consists mainly of red quartz arenite. Marine dolomite pinches out eastward. The Sikosak Formation, at least 150 m of white quartz arenite, contains 0-30 m of basalt flows of the Hansen Formation, which, descending westward in the Sikisak, suggest that the tidal marine unit migrated west. The Agu Bay Formation contains a 0-10 m basal stromatolitic shallow-water dolomite member, a 75 m marine shelf black shale member, both absent in the east, and a 500 m thick upward-coarsening and shoaling redbed member. Pinkish white quartzite of the shallow marine Whyte Inlet Formation thins west from 3 km to bare mappability. The Autridge Formation, with a lower Mikkelsen Member, 1500 m of drab quartz arenite and black shale, and an upper Cape Appel Member, 500 m of black shale, may be an outer shelf equivalent of the Whyte Inlet.

Uranium occurs in the subjacent granitic basement and in a quartz stockwork occupying a fault in the Nyeboe Formation.

Résumé

Le groupe de Fury et Hecla représente un miogéoclinal légèrement incliné, non métamorphisé; son épaisseur et de 6 000 m et il se compose de quartzarénite et de petites quantités de schiste argileux et de dolomie. La datation au K-Ar de roches volcaniques et intrusives mafiques entières indique que ces roches datent du Néohélikien ou du Hadrinien. Il existe une corrélation entre ce groupe et la partie inférieure du supergroupe de Bylot, à 200 km au nord. Le groupe de Fury et Hecla et le supergroupe de Bylot se seraient accumulés surtout en un milieu marin peu profond, l'océan se trouvant à l'ouest ou au nord-ouest. La formation basale de Nyeboe, d'origine alluviale, a une épaisseur de 500 m et se compose surtout de quartzarénite rouge. De la dolomie d'origine marine disparaît progressivement en biseau vers l'est. La formation de Sikosak se compose d'au moins 150 m de quartzarénite blanche, et contient des coulées de basalte de la formation de Hansen; ces coulées de basalte, dont l'épaisseur varie de 0 à 30 m, ont pénétré plus profondément dans la formation de Sikosak vers l'ouest, ce qui porte à croire que l'unité marine tidale s'est déplacée vers l'ouest. La formation d'Agu Bay se divise en trois termes, les deux premiers étant absents à l'est. Le premier terme comprend une dolomie stromatolitique basale dont l'épaisseur varie de 0 à 10 m, qui s'est accumulée en eau peu profonde. Le deuxième terme se compose de schiste argileux noir d'une épaisseur de 75 m, accumulé sur une plate-forme marine. Le troisième est une couche rouge de 500 m d'épaisseur dans laquelle les matériaux deviennent grossiers en progressant vers le haut, qui s'est accumulée dans un milieu où il y avait formation de hauts-fonds. La formation de Whyte Inlet, se compose de quartzite blanc rosâtre ayant une épaisseur de 3 km et qui s'amincit vers l'ouest pour disparaître presque complètement. La formation d'Autridge pourrait être l'équivalent de la formation de Whyte Inlet, mais accumulée sur une plate-forme extérieure; elle se divise en un terme inférieur de 1 500 m d'épaisseur, le terme de Mikkelsen, qui se compose de quartzarénite terne et de schiste argileux noir, et d'un terme supérieur de 500 m d'épaisseur, celui de Cape Appel, qui se compose de schiste argileux noir.

On trouve de l'uranium dans le socle granitique sous-jacent et dans un stockwerk de quartz occupant une faille dans la formation de Nyeboe.

Summary

Along the north shore of Fury and Hecla Strait the miogeoclinal Fury and Hecla Group is 6000 m thick. It consists of 4000 m of mainly red and white quartz arenite divided into five newly named formations and the 2000 m thick overlying Autridge Formation that consists of drab quartz arenite and black shale. A preliminary U-Pb zircon age of 1817 ± 14 Ma from the underlying granitic basement and K-Ar whole-rock ages of about 1100 Ma from basalt flows near the base of the group and of 746-631 Ma from mafic dykes and the Dybbol Sill, both cutting the group, give the group a Neohelikian to Hadrynian age.

Although a general correlation with the lower part of the Bylot Supergroup, 200 km to the north, is supported, coarse grained fault-related facies, used to postulate deposition of the Bylot Supergroup in a west-opening failed arm are absent. As in the Bylot

Sommaire

L'épaisseur du groupe miogéoclinal de Fury et Hecla atteint 6 000 m le long de la rive nord du détroit de Fury et Hecla. Ce groupe comprend une zone de 4 000 m d'épaisseur qui se compose surtout de quartzarénite rouge et blanche et qui se divise en cinq formations nouvellement nommées. Il comprend aussi la formation susjacente d'Autridge dont l'épaisseur est de 2 000 m et qui se compose de quartzarénite terne et de schiste argileux noir. La datation à l'U-Pb des zircons tirés du socle granitique sous-jacent donne un âge provisoire de 1 817 ± 14 millions d'années; la datation au K-Ar des roches entières indique que les coulées de basalte situées près de la base du groupe dateraient d'environ 1 100 millions d'années, tandis que les filons mafiques et le sill de Dybbol qui recoupent le groupe daterait de 746 à 631 millions d'années; le groupe daterait donc du Néohélikien ou du Hadrynien.

Bien qu'il existe une corrélation générale entre le groupe de Fury et Hecla et la partie inférieure du supergroupe de Bylot à 200 km au nord, le groupe de Fury et Hecla ne contient pas les

Supergroup, distribution and nature of sedimentary and volcanic units are consistent with deposition both in alluvial and shallow marine environments. They also support a suggestion, made for the Bylot Group, of a rifting ocean opening in the west or northwest.

The Fury and Hecla Group overlies a Hudsonian basement consisting of granitic gneiss and plutons and minor metasediments of high metamorphic grade. On limited evidence the unconformity beneath the group appears unweathered.

The basal formation, the Nyeboe Formation (1), about 500 m thick, consists mainly of red quartz arenite, its lower part slightly feldspathic. Basal granitic conglomerate is virtually absent. Because heavy felsenmeer cover prevented certain subdivision of this probably complex formation, seven informal members are suggested as follows: (a) local basal polymict breccia, only a few metres thick; (b) red sandstone and shale member, with desiccation cracks; (c) west-thinning and fining quartz-pebble conglomerate with a clast fabric common in fluvial conglomerate; (d) red sandstone and mudcracked shale; (e) dolomitic quartz arenite and stromatolitic dolomite with herringbone crossbeds; (f) altered oxidied basalt with amygdules, that pinches out eastward and (g) red sandstone with mudcracks. Westward thinning and the fluvial fabric of member (c) and eastward pinchout of member (e) suggest alluvial to shallow marine deposition, with marine conditions to the west.

The Sikosak Formation (2), at least 150 m thick, is a resistant white to light pink quartz arenite. It has abundant linear wave-ripples, some herringbone crossbeds and high textural and mineralogical maturity. The formation was probably deposited under shallow marine conditions. Wave ripple orientation suggests a north trending shoreline.

The 0-30 m thick Hansen Formation (3) is absent in the east of the area. It consists of green to black unoxidized basalt and occurs increasingly lower in the Sikosak Formation westward, suggesting that the latter was deposited as a westward migrating facies belt. Chemical analyses suggest that the Hansen Formation, with member (f) of the Nyeboe Formation is plateau basalt related to initial ocean opening.

The Agu Bay Formation (4) includes three members: (a) a local, basal, 0-10 m thick, shallow water stromatolitic dolomite member with oncolites, oolites, mudcracks, and truncated stromatolites; (b) a succeeding 75 m thick black shale member which contains upward-coarsening grey quartz-and calc-arenite beds with syneresis cracks and herringbone crossbeds and (c) an overlying redbed member, 500 m thick, which with the black shale member comprises an upward-coarsening megacycle deposited under conditions shoaling to emergence. The redbed member coarsens upward from red shale to red sandstone but is mainly sandy in the east. It contains smaller scale upward-coarsening hemicycles, 10-15 m thick (mesocycles), that mimic the megacycle. The upper parts of the second order mesocycles are composed of red quartz arenite containing herringbone crossbeds and upward-fining flood cycles about 15 cm thick (minicycles) that terminate in desiccation-cracked mud layers. The dolomite and black shale members are absent in the eastern third of the area. The dolomite member was probably deposited on high energy tidal flats. The black shale member is of marine shelf origin. The included sand beds were possibly deposited by tidal currents. With the black shale

faciès à grain grossier, liés à des failles, qui portent à croire que le supergroupe de Bylot s'est accumulé dans un bras effondré s'ouvrant vers l'ouest. La répartition et la nature des unités sédimentaires et volcaniques du groupe de Fury et Hecla et du supergroupe de Bylot portent à croire que ces roches se sont accumulées dans un milieu marin peu profond et dans un milieu alluvial. Dans le cas du groupe de Bylot, elles indiquent également qu'il y avait formation de fossés d'effondrement dans un océan qui s'ouvrait à l'ouest ou au nord-ouest.

Le groupe de Fury et Hecla repose sur un socle hudsonien composé de gneiss granitique, de plutons et de petites quantités de métasédiments fortement métamorphisés. D'après certains indices limités, la discordance sous-jacente n'aurait pas subi d'altération.

La formation basale de Nyeboe (1) a près de 500 m d'épaisseur et se compose surtout de quartzarénite rouge; sa partie inférieure est légèrement fledspathique. On n'y trouve essentiellement pas de conglomérat granitique basal. La présence d'un épais champ de pierres empêche la subdivision certaine de cette formation vraisemblablement complexe; cependant, sept termes officieux y ont été identifiés: (a) une brèche polygénique basale que l'on trouve par endroits et qui n'a que quelques mètres d'épaisseur; (b) un terme composé de grès rouge et de schiste argileux et comportant des fentes de dessiccation; (c) un conglomérat à cailloux de quartz dans lequel les clastes sont orientées comme dans bon nombre de conglomérats fluviatiles; le conglomérat s'amincit vers l'ouest et son grain diminue progressivement dans cette même direction; (d) un grès rouge et un schiste argileux fissuré par dessiccation; (e) une quartzarénite dolomitique et une dolomie stromatolitique à stratification oblique en chevron; (f) un basalte amygdaloïde oxydé, altéré, qui disparaît progressivement en biseau vers l'est et (g) un grès rouge fissuré par dessiccation. L'amincissement vers l'ouest et la texture fluviatile du terme (c) ainsi que la disparition progressive en biseau vers l'est du terme (e) portent à croire que ces termes se sont accumulés dans un milieu alluvial ou dans un milieu marin peu profond et qu'une mer se trouvait vers l'ouest.

La formation de Sikosak (2) a au moins 150 m d'épaisseur et se compose d'une quartzarénite résistante dont la couleur varie du blanc au rose pâle. Elle contient un grand nombre de rides d'oscillation linéaires et quelques strates obliques en chevron et présente une grande maturité texturale et minéralogique. La formation se serait accumulée dans un milieu marin peu profond. L'orientation des rides d'oscillation porte à croire que le rivage était orienté nord-sud.

La formation de Hansen (3), dont l'épaisseur varie de 0 à 30 m, n'est pas trouvée dans la partie est de la région. Elle se compose de basalte inoxydé vert ou noir et se trouve progressivement plus bas dans la formation de Sikosak plus on s'avance vers l'ouest, ce qui porte à croire que la Sikosak s'est accumulée dans une zone de faciès qui se déplaçait vers l'ouest. Les résultats d'analyses chimiques portent à croire que la formation de Hansen et le terme (f) de la formation de Nyeboe se composent de basaltes des plateaux liés à l'ouverture initiale de l'océan.

La formation d'Agu Bay (4) se divise en trois termes: (a) un terme basal dont l'épaisseur varie de 0 à 10 m et que l'on trouve à certains endroits seulement; il se compose de dolomie stromatolitique accumulée en eau peu profonde et contenant des oncolites, des oolites, des fentes de dessiccation et des stromatolites tronqués; (b) un schiste argileux noir d'une épaisseur de 75 m qui contient des couches grises de quartzarénite et de calcarénite dans lesquelles les matériaux deviennent grossiers en progressant vers le haut; ces couches contiennent des fissures de synérèse et des strates obliques en chevrons et (c) une couche rouge sous-jacente ayant une épaisseur de 500 m qui, avec le terme du schiste argileux noir, forme un mégacycle où les matériaux deviennent grossiers en progressant vers le haut, qui s'est accumulé dans un milieu où il y avait formation de hauts-

member the redbed member represents a regressive megacycle. The third order minicycles probably represent subaerial coastal flood cycles.

The Whyte Inlet Formation (5), is composed of white to purple, generally pink quartz arenite, with pebble layers in the upper part, mainly in the east. Three kilometres thick in the centre of the area and at least 2 km thick in the east, it thins westward until at the western margin of the area it is represented only by some tens of metres of interbedded pink quartzite and red sandstone. High mineralogical and textural maturity of the quartz grains and the zircon grains in the quartz arenite, dominance of wave over current ripples, and absence of criteria of other environments suggest a shallow marine mode of deposition.

The overlying Autridge Formation (6), is divided into the lower Mikkelsen Member, which consists of 1500 m of drab quartz arenite and black shale, and the Cape Appel Member, consisting of 500 m of black shale. Absence of signs of emergence, colour of the shale and an abundance of syneresis cracks point to a marine mode of deposition, perhaps the outer-shelf distal equivalent of the Whyte Inlet Formation.

Prehnite and pumpellyite in basalt amygdules point to a subgreenschist facies regional (burial) metamorphism of the Fury and Hecla Group. In general strata dip gently southward. They are intruded by the mafic Dybbol Sill and by northwest-trending mafic dykes. Northwest- and west-trending normal faults are upthrown to the south.

Uranium mineralization occurs in granites, pegmatites and oxidized shear zones in the basement adjacent to the unconformity beneath the Fury and Hecla Group. It also occurs in a quartz stockwork that occupies a fault cutting the Nyeboe Formation. Carbonates on the north shore of the strait are very thin and show little sign of basemetal mineralization. Carbonates on Amherst Island in Fury and Hecla Strait are possibly correlative with those containing the Nanisivik zinc-lead deposit in the Bylot Supergroup. Nine grab samples from the hematitic quartz conglomerate of the Nyeboe Formation were assayed for gold but failed to yield significant results.

fonds, voire émergence. Les matériaux qui composent la couche rouge deviennent plus grossiers vers le haut, passant d'un schiste argileux rouge à un grès rouge; le terme est surtout sableux à l'est. Il contient des hémicycles plus petits dont l'épaisseur varie de 10 à 15 m (mésocycles) et qui ressemblent aux mégacycles; les matériaux qu'ils contiennent deviennent plus grossiers en progressant vers le haut. Les parties supérieures des mésocycles de second ordre se composent de quartzarénite rouge à stratification oblique en chevrons, et contiennent des cycles d'inondation à granoclassement vertical dont l'épaisseur est d'environ 15 cm (minicycles) et qui se terminent dans les couches de boue fissurées par dessiccation. On ne trouve pas les termes composés de dolomie et de schiste argileux noir dans le tiers est de la région. Le terme dolomitique se serait accumulé sur des slikkes à forte énergie. Le schiste argileux noir s'est accumulé sur une plate-forme marine. Les couches sableuses qu'elle contient ont vraisemblablement été déposées par des courants de marée. Le terme du schiste argileux noir et celui de la couche rouge représentent un mégacycle régressif. Les minicycles de troisième ordre représentent probablement des cycles d'inondation côtière subaérienne.

La formation de Whyte Inlet (5) se compose de quartzarénite blanche ou violette mais généralement rose; la partie supérieure de cette formation contient des couches de galets, surtout dans la partie est de la région. La formation a une épaisseur de 3 km au centre de la région et d'au moins 2 km à l'est; elle s'amincit vers l'ouest pour n'être représentée que par quelques dizaines de mètres de quartzite rose et de grès rouge interstratifiés à l'extrémité ouest de la région. La forte maturité minéralogique et texturale des grains de quartz et de zircon dans la quartzarénite, la prédominance des rides d'oscillation par rapport aux rides de courant et l'absence de caractéristiques d'autres milieux portent à croire que la formation s'est accumulée dans un environnement marin peu profond.

La formation sus-jacente d'Autridge (6) se divise en deux termes. Le terme inférieur, celui de Mikkelsen, se compose de quartzarénite terne et de schiste argileux noir sur une épaiseur de 1 500 m. Le terme de Cape Appel se compose de 500 m de schiste argileux noir. L'absence d'indices d'émersion, la couleur du schiste argileux et l'abondance des fissures de synérèse laissent croire que la formation s'est accumulée dans un milieu marin et qu'elle serait l'équivalent de la formation de Whyte Inlet, mais accumulée sur une plate-forme extérieure.

La présence de préhnite et de pumpellyite dans les vacuoles du basalte laisse croire que le groupe de Fury et Hecla a subi un métamorphisme régional (d'enfouissement) menant au faciès sous celui des schistes verts. En général, les couches s'inclinent doucement vers le sud. Elles sont coupées par le sill mafique de Dybbol et par des filons mafiques à orientation nord-ouest. Des failles normales sont orientées nord-ouest et ouest et leurs compartiments soulevés se trouvent du côté sud.

Des granites, des pegmatites et des zones de cisaillement oxydées dans le socle contigu à la discordance sous le groupe de Fury et Hecla contiennent de l'uranium. On trouve également de l'uranium dans un stockwerk de quartz qui occupe une faille recoupant la formation de Nyeboe. Les roches carbonatées de la rive nord du détroit sont très minces et ont été très peu minéralisées en métaux communs. Les roches carbonatées de l'île Amherst dans le détroit de Fury et Hecla pourraient être mises en corrélation avec celles qui contiennent le gisement plombo-zincifère de Nanisivik dans le supergroupe de Bylot. Neuf échantillons prélevés au hasard dans le conglomérat siliceux hématitique de la formation de Nyeboe ont été analysés pour en évaluer la teneur en or mais n'ont pas donné de résultats significatifs.

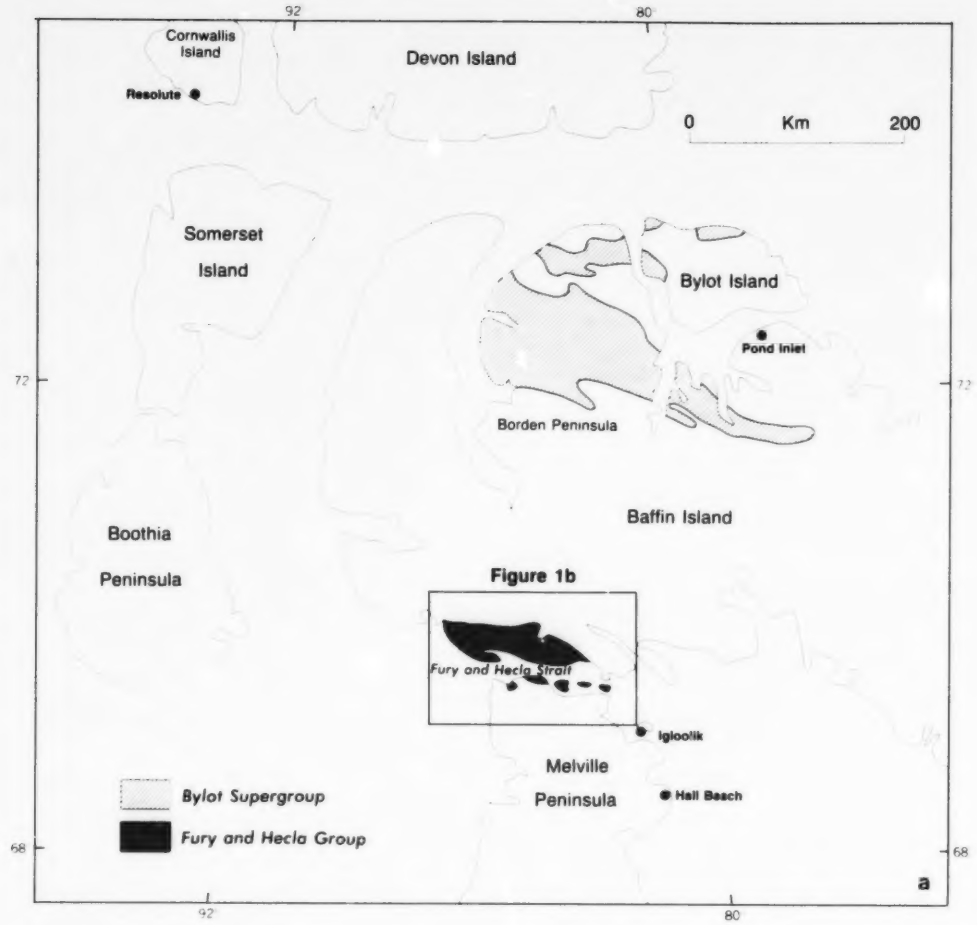
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Figure 1b
Fury and Hecla Strait
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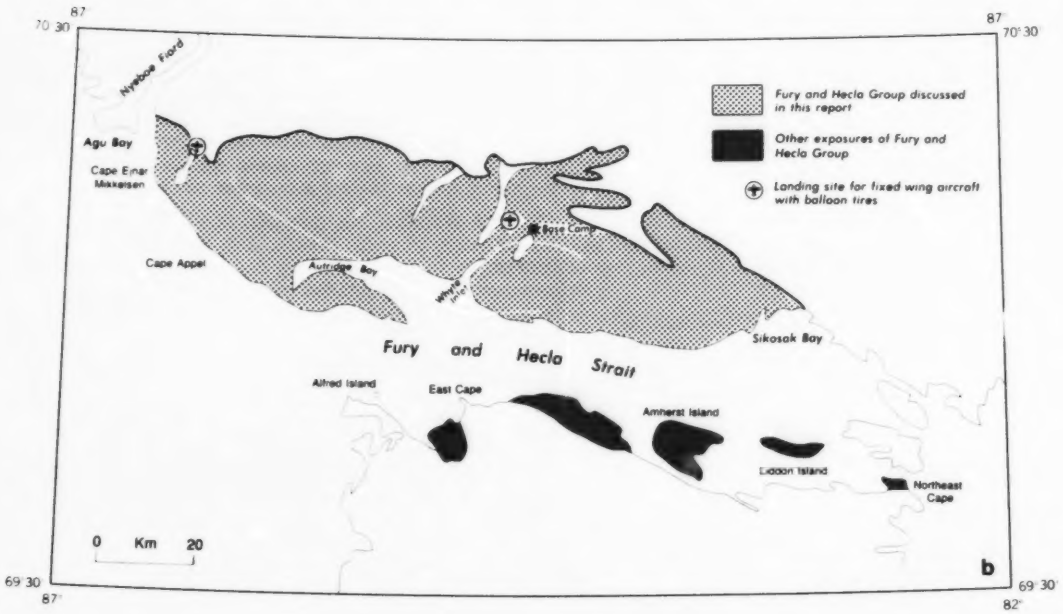
Melville Peninsula
Hall Beach
Bylot Supergroup
Fury and Hecla Group
68
a


87
70° 30'
Nyeboe Fjord
Agu Bay
Cape Einar Mikkelsen
Cape Appel
Autridge Bay
Base Camp
Fury and Hecla Group discussed in this report
Other exposures of Fury and Hecla Group
Landing site for fixed wing aircraft with balloon tires
Sikosak Bay
Fury and Hecla Strait
Alfred Island
East Cape
Amherst Island
Liddon Island
Northeast Cape
0 Km 20
69° 30'
82°
b

INTRODUCTION

Location and access

This report describes the geology of the Fury and Hecla Group on Baffin Island north of Fury and Hecla Strait. The study was undertaken to investigate a virtually unknown major sequence of late Precambrian supracrustal rocks, about 6 km thick, that is similar in lithology and geological setting, including the presence of anomalous radioactivity, to the Athabasca Group in Saskatchewan. The discovery of numerous high grade, unconformity-related uranium deposits in the Athabasca Group (Hoeve and Sibbald, 1978; Munday, 1979) prompted the present investigation in 1979.

The area studied (Fig. 1) lies in the centre of NTS map sheet 47 on Baffin Island, on the north shore of Fury and Hecla Strait. It extends east-west along the Baffin Island coast between longitudes 83° and 86°30'W for about 150 km, reaching north into the interior from latitude 69°55' to 70°20'N, a maximum distance of 35 km.

The area is uninhabited except for a small Inuit encampment at the western margin at Agu Bay, a good location for hunting polar bears. The settlements of Igloolik and Hall Beach lie 140 and 180 km to the southeast and are serviced by Bradley Air Services' Twin Otter. Hall Beach is reached by jet aircraft from Montreal.

The area is barren and extensively covered by felsenmeer. Some stream valleys and low meadows are well grassed and provide pasture for several herds of caribou numbering a few dozen animals, which according to local report are multiplying.

Shaly units in the Fury and Hecla Group underlie wet clayey ground that can be difficult to cross on foot. The highest ground, a coast-parallel range of rounded hills rising to 600 m, is underlain by quartzite, from which the terrain falls gently southward to the coast, much of which is margined by a series of raised beaches up to 3 km wide. North of the quartzite ridge the land falls to the granitic basement underlying the Fury and Hecla Group where elevations average 300 m and local relief is rugged on a scale of tens of metres.

In summer 1978 fuel and camp equipment were sent by sea from Montreal to Hall Beach. During the succeeding winter the supplies were cached at a base camp (Fig. 1b) at the north end of a lake 11 km northeast of the north end of Whyte Inlet. Two subsidiary fuel caches were placed in the west of the area by Twin Otter on skis landing on lake ice. At the same time an emergency cache of 250 kg of frozen meat and other non-perishable foods was placed with Andris Rode at the Arctic Research Centre at Igloolik in case poor weather prevented communication with Montreal during the field operation.

At the start of the field operation telecommunications were set up with the Department of Energy, Mines and Resources' Polar Continental Shelf Project at Resolute Bay, Cornwallis Island, with Bradley Air Services at Hall Beach and Pond Inlet, and with A. Rode at Igloolik.

The interior of the area is accessible in early July, by landing ski-equipped aircraft on lake ice. Landing sites for wheeled aircraft after breakup are restricted to a few lakeshore sites (Fig. 1b). Some landing sites may exist on coastal raised beaches, but were not investigated by the writer. A Bell Jet Ranger helicopter, chartered from Okanagan Helicopters Ltd. of British Columbia by the Polar Continental Shelf Project, was used to bring supplies from Hall Beach and Igloolik and to set out personnel in the field.

Previous and present fieldwork

European activity in the region commenced early in the seventeenth century with mainly British naval expeditions, continued through the whaling period of the nineteenth century, and then led to expeditions early in the twentieth century by the Canadian Government to assert its sovereignty. These and subsequent voyages are listed by Blackadar (1970) who carried out "Operation Admiralty", the first regional geological reconnaissance in the area, the results of which are also published in several maps (Blackadar, 1958; Blackadar et al., 1968a, b).

Radioactive anomalies were outlined by lake sediment geochemical surveys in the granitic basement adjacent to the unconformably overlying Fury and Hecla Group by Noranda Exploration Ltd. in 1975 (Assessment Files, Department of Indian and Northern Affairs). Airborne and ground radiometric surveys and geological mapping showed the strongest anomalies to be due to thorium-rich granites and pegmatites, and the smaller anomalies to be caused by concentrations of granitic boulders overlying the Fury and Hecla Group (Gibbins, 1976).

As part of the 1977 Uranium Reconnaissance Program of the Geological Survey of Canada an airborne gamma-ray spectrometric survey was flown over the Fury and Hecla Strait area. The resulting geophysical maps 35547G (Erichsen Lake) and 35647G (Agu Bay) show that the above radioactivity occurs in two separate areas, each about 20 km across and lying about 50 km apart. The anomalies mainly overlie basement rocks adjacent to the basal nonconformity of the Fury and Hecla Group, and were later discovered (Chandler et al., 1980) to coincide with uranium-rich granite bodies.

Recently both in northwestern Australia (Ferguson and Goleby, 1980) and in western Canada (Munday, 1979), important uranium deposits have been discovered at and near the contact between early- to mid-Proterozoic

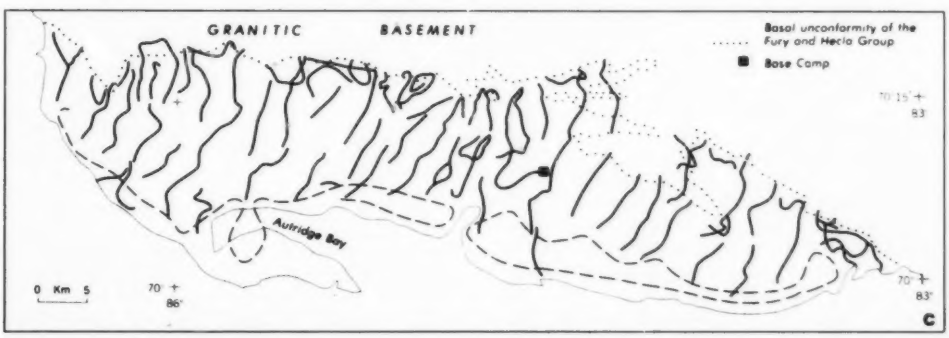


Figure 1. Location maps (a) Northwest Baffin Island, (b) Fury and Hecla Strait area, (c) Ground traverse (–) and helicopter traverse (---) coverage of the Fury and Hecla Group.

metamorphosed uraniferous sequences and overlying unmetamorphosed flat-lying quartz arenite sequences. Because of the similarities between the geology of these two areas and that of the Fury and Hecla Strait area it was decided to mount a multidisciplinary field operation with some emphasis on the rocks which might be mineralized.

Thus in summer 1979 the writer led a multidisciplinary field party into the area. The igneous geology of the radioactive granites and adjacent gneisses was studied by A. Ciesielski and J. Maley. The radioactivity of the basement and cover rocks was investigated by B.W. Charbonneau and Y.T. Maurice. The 6 km thick overlying mainly quartz arenite sequence, the Fury and Hecla Group, was studied by the writer assisted by A. Legun and B. Zaitlin. The results of the third study make up this report. A paleomagnetic study of the sedimentary rocks and mafic igneous rocks within them was carried out by Sandra White and her thesis supervisor H.C. Palmer of the University of Western Ontario to aid in deciphering relative age and paleoclimatology (paleolatitude).

Due to snow cover it was not possible to start mapping near sea level until the end of June. Mapping in the high ground in the western part of the area was delayed until mid-July for the same reason. Mapping the sedimentary sequence was accomplished during the six weeks of July and early August. Logistical constraints prevented examination of equivalent strata on the islands in Fury and Hecla Strait and on the south shore of the strait.

The heavy felsenmeer and drift cover over most of the area neccessitated heavy reliance on mapping the loose blocks instead of the bedrock. Because of glacial transport geological contacts were found by walking along the direction of Pleistocene ice movement across the strike of the Helikian sedimentary rocks at intervals of 1-6 km depending on the complexity of the geology (Fig. 1c). The helicopter was used daily to place and collect mapping teams and to run air traverses searching for exposures among the coastal raised beaches. Units traceable in the field are shown in the accompanying map in the pocket (Fig. 2). Markedly greater detail, found in some canyon walls, and described in the text, gave significantly more insight into the sedimentology of parts of the sequence than would have otherwise been possible.

Acknowledgments

The writer, A. Legun and Brian Zaitlin, who mapped the supracrustal rocks were assisted by Quentin Gall and Glen Griesbach. John McCaw of Bradley Air Services, base manager at Hall Beach provided excellent Twin Otter service. Andris Rode, manager of the support services of the Arctic Research Centre at Igloolik, gave excellent logistical support. Roland Senneville prepared nutritious food. Jennifer Graves assisted with preparation of zircon samples for petrography.

GENERAL GEOLOGY

Granitic basement

The rocks to the north of the late Proterozoic Fury and Hecla Group were first systematically described by Blackadar (1958, 1963, 1970) who described biotite-quartz-feldspar granite and granitic gneiss with abundant cross-cutting granitic pegmatite and, along the shores of Nyeboe Fjord, up to 12 km north from Agu Bay, abundant hybrid (biotite-amphibole) gneiss. Although there is clear lithological variation in the basement rocks, great difficulty was found in establishing mappable units. Blackadar (1970, p. 31) cited 5 radiometric ages from the basement as evidence for an "Aphebian (Hudsonian) age for the latest metamorphism" affecting them. This is supported by a recent Rb-Sr isochron age of 1817 ± 14 Ma determined at the Geological Survey of Canada.

As mentioned above a recent airborne radiometric study by the Geological Survey of Canada outlined two large more or less circular radiometric anomalies in the basement rocks, one centred at longitude 86°00' and latitude 70°30' and the other at longitude 84°20' and latitude 70°18' (see Chandler et al., 1980, Fig. 20.1, 20.2). Preliminary results of the geological field study of the rocks underlying the anomalies are given by Ciesielski (in Chandler et al., 1980) and by Ciesielski and Maley (1980). Later work on these rocks is summarized in the section below on uranium mineralization.

Fury and Hecla Group

Two thick, probably late Precambrian supracrustal sequences occur in northwestern Baffin Island (Fig. 1a) one, the Fury and Hecla Group (Blackadar, 1970; Chandler et al., 1980) and the other, the Eqalulik and Uluksan groups (Blackadar, 1970; Jackson and Davidson, 1974; Jackson et al., 1975, 1978). Jackson and Ianelli (1981) recently separated the upper part of the Uluksan Group as the newly created Nunutsiaq Group, arranging the three groups into the new Bylot Supergroup. The Bylot Supergroup is overlain by Early Paleozoic strata, (Trettin, 1969).

Blackadar (1958) referred to a considerable thickness of reddish-brown to yellowish-orange sandstone, conglomerate and grit of Proterozoic and/or Paleozoic age lying on the north shore of Fury and Hecla Strait. Lemon and Blackadar (1963) mentioned a thickness of 3 km or more and noted that the strata were intruded by numerous gabbro sills. They suggested that these rocks were probably equivalent to the Eqalulik Group (lower part of the Bylot Supergroup of Jackson and Ianelli, 1981). Blackadar (1970) named the sandstone sequence the Fury and Hecla Formation and suggested a thickness of over 4.5 km. He described the sequence as primarily composed of greyish orange-pink to pale red, massive- to medium-bedded quartzite to quartzitic sandstone with minor grit, red and black shale and local basal conglomerate. Minor quartz-pebble conglomerate and grit layers were found in the lower part, but not at the base of the section. Apart from the reinterpretation of mafic sills as volcanic rocks, the writer has vindicated two partial sections assembled by Blackadar (1970).

Fieldwork in 1979 showed that Blackadar's Fury and Hecla Formation is divisible into five formations (see Table of Formations and Fig. 2 and 3) and should be given group status. Also some of the new formations are divisible into mappable members. The new formations and some of the members are formally named after the sparsely named geographic features, as close as possible to where the units are thick and best exposed. The basal formation, the Nyeboe, contains several units but since they cannot be followed owing to the overburden, seven unnamed informal members are suggested. This division of the Fury and Hecla Group is different from that used in an interim report by Chandler et al. (1980).

Overlying his Fury and Hecla Formation, Blackadar (1970) mapped and defined the Autridge Formation consisting of a sequence of at least 450 m of black shale, siltstone, dolomite and limestone (Balckadar, 1958, 1963, 1965) exposed in the vicinity of Autridge Bay, west to Cape Appel and on Alfred, Amherst and Lidden islands in Fury and Hecla Strait. The formation is a possible equivalent of the lithologically similar lower part of the Uluksan Group that lies farther north on Baffin Island (Blackadar, 1970). Near Cape Appel the transitional base appears as siltstone

Table of Formations

EON	ERA	FORMATION	LITHOLOGY	THICKNESS (m)
PROTEROZOIC	NEOHELIKIAN TO HADRYNIAN		Diabase sills and dykes	
		Intrusive contact		
		Autridge	Interbedded drab sandstone, siltstone and black shale, black shale	2000
		Whyte Inlet	Pink to white and purple quartz arenite	at least 0-3000
		Agu Bay	Red sandstone and shale, minor black shale and stromatolitic dolomite	up to ~600
		Hansen*	Basalt flows	0-30?
		Sikosak Bay	White quartz arenite	150+
		Nyeboe	Red quartz arenite; minor feldspathic sandstone, red shale, polymict and quartz conglomerate, dolomite-cemented quartz arenite, stromatolitic dolomite, red basalt flows	~300
		Nonconformity		
	APHEBIAN	Granitic Basement	Granitic and minor mafic gneiss, granitic plutons	

*Underlies Sikosak Bay Formation in west (see text).

beds a few centimetres thick in quartzites of the Fury and Hecla Formation. The siltstone, rich in mudcracks (interpreted by Chandler et al. (1980) to be syneresis cracks) becomes the dominant lithology and then passes up into black shale and slate with thin dolomite beds in the type section west of Autridge Bay (Blackadar, 1970).

Within the area mapped, the Autridge Formation consists of a sequence of drab quartz arenite and interbedded black shale followed by black shale with minor thin quartz arenite beds, here formally named the Mikkelsen and Cape Appel members. Although these members are thick enough to be formations it was thought that elevation of the Autridge Formation to group status should await study of the overlying units of the formation that underlie the islands in Fury and Hecla Strait.

The formations and members of the Fury and Hecla Group are described below, with locations of reference sections where available.

Basal unconformity and regolith

Heywood, who mapped the basement beneath the Fury and Hecla Group on the southern side of Fury and Hecla Strait reported (personal communication, 1981) red staining of the gneisses adjacent to the unconformity, interpreting this discolouration to be due to weathering, but in his report (Heywood, 1974) he did not mention weathering. Neither Lemon and Blackadar (1963) nor Blackadar (1970) referred to a regolith beneath the Bylot Supergroup (Eqalulik and Uluksan groups) or Fury and Hecla Group (Formation). On the other hand Jackson and Ianelli (1981) found red staining to be a common occurrence up to several metres beneath the unconformity at the base of the Bylot Supergroup. At two locations regolith up to 6 m thick was described as containing quartz and kaolinized feldspar in a chloritic matrix.

On most traverses in this study the unconformity between the granitic basement and the overlying Nyeboe Formation was found to be obscured by bouldery drift containing abundant granitic boulders and red sandstone flags containing white "clay minerals", thought in the field to be kaolinite but discovered from thin section to be muscovite.

In some cases the unconformity was replaced by a high angle fault. At one locality 6 m of sheared red grit with granite pebbles directly overlies the apparently unweathered basement. Because the shear surface and the contact with the basement dip steeply it is likely that the contact is faulted. At another locality trough-crossbedded red sandstone dips gently southeast and overlies fresh fine grained granular biotite gneiss with a 0.5 m covered interval intervening.

Thus only fresh granitic rocks were seen by the writer adjacent to the unconformity. Further, no sign was found of altered granitic boulders in the drift near the unconformity,

an observation contrary to that of M. Schau (personal communication, 1983) who worked on the south shore of Fury and Hecla Strait.

From the foregoing, one certainly must conclude that a regolith is not as strongly developed beneath the Fury and Hecla Group as beneath some other Helikian (Chandler and Stevens, 1981) quartz sandstones of the Canadian Shield, e.g. the Athabasca Group (MacDonald, 1980) and the Thelon Formation (Donaldson, 1966). There is, however, some evidence, albeit contradictory, of weathering. The apparent contradiction might be due to removal of weakly developed regolith from elevations and its sedimentation in depressions. Clearly the matter is in need of further examination.

The regolith question may be of significance in view of the rich uranium mineralization at the base of the Athabasca Group (see section on Economic geology, uranium).

Nyeboe Formation

This unit, named after Nyeboe Fjord which lies immediately northwest of the area mapped at 86°30', consists of about 500 m of sedimentary strata and a thin mafic volcanic unit lying between the basement and the overlying Sikosak Bay Formation. In the western part of the area, due to the diachronous nature of the Sikosak Bay Formation, the Nyeboe Formation is overlain by the Hansen Formation, which rises up through the Sikosak Bay Formation eastward (see Table of Formations and Fig. 2 and 3). Rare canyon sections show a complex internal stratigraphy with lateral facies changes, indicating that the stratigraphy of the Nyeboe is probably more complex than shown below. From over 50 complete and partial traverses across the unit a stratigraphic column was developed which comprises the following informal members in ascending stratigraphic order.

7. Red sandstone member
6. Altered basalt member
5. Dolomitic quartz arenite and stromatolitic dolomite member
4. Red sandstone and shale member
3. Quartz conglomerate member
2. Red sandstone and shale member
1. Local basal polymict breccia member

As with the formations within the Fury and Hecla Group the distribution and thickness of the members of the Nyeboe Formation is uneven (Fig. 3) along the north shore of the Fury and Hecla Strait. Member 1 occurs only locally. Members 2, 4 and 7 diminish in thickness eastward, being entirely replaced by red to pink quartzite at the eastern limit of the area. Similarly member 5, like the stromatolitic dolomite member of the Agu Bay Formation pinches out eastward, not being visible east of longitude 84°. The quartz-clast conglomerate, member 3, however, both thickens and coarsens eastward.

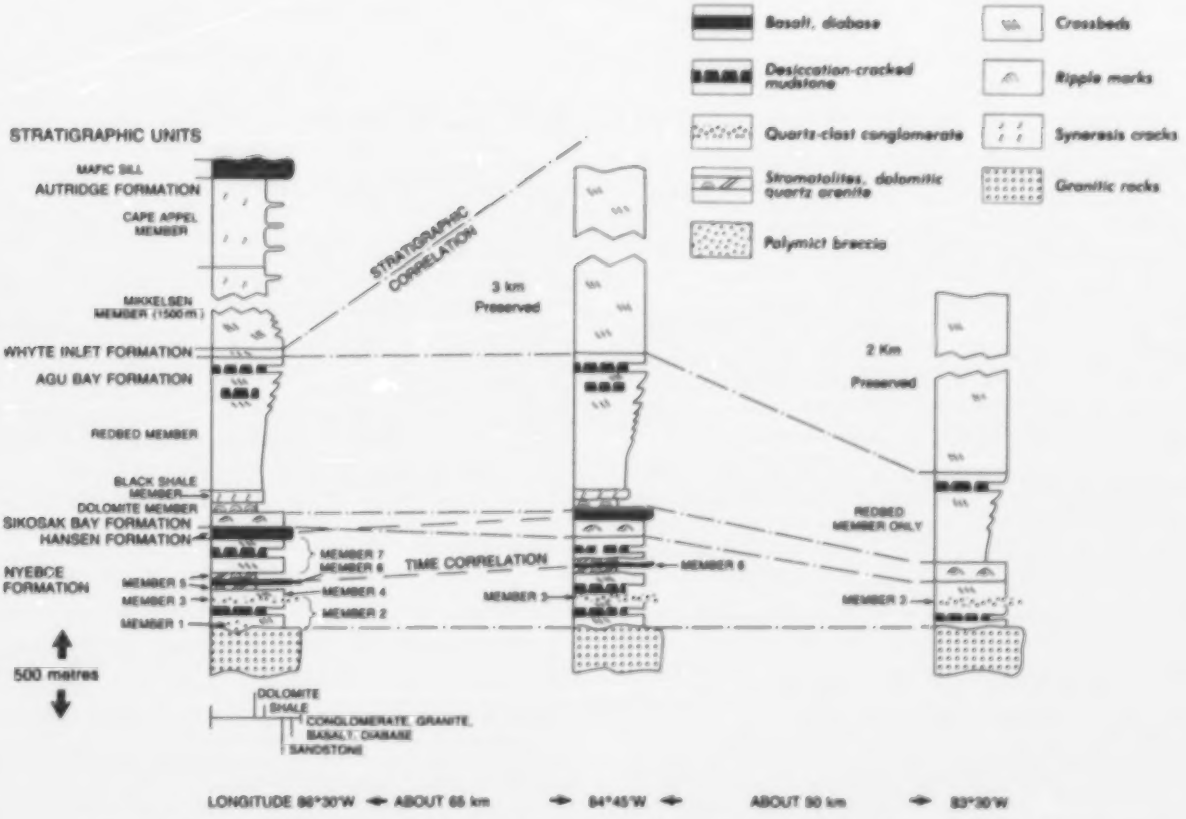


Figure 3. Composite, schematic columns to show stratigraphic changes in the Fury and Hecla Group along the north shore of Fury and Hecla Strait. Thickness of units under 200 m is exaggerated.

Member 1, polymict breccia

The basal polymict breccia is visible only in the extreme west at site L 326 (Fig. 2, in pocket) where it is only a few metres thick and consists of a great variety of clasts including schist, quartzite, iron formation and granite. At its basal contact clasts rest in a greenish-grey dolomite matrix. The unit grades up to a grey dolomitic sandstone. Similar sandstone was seen at the base of the Nyeboe Formation 800 m east of this exposure.

One thin section from the breccia member, at locality L 360, consists of little-weathered, poorly sorted and rounded grit, composed mainly of granitic fragments set in a sparsely hematitic, angular, very fine grained quartzofeldspathic sand matrix. Several per cent of clear dolomite grains have replaced some feldspathic clasts and other dolomite crystals appear to have formed diagenetically in the matrix.

Member 2, red sandstone and shale

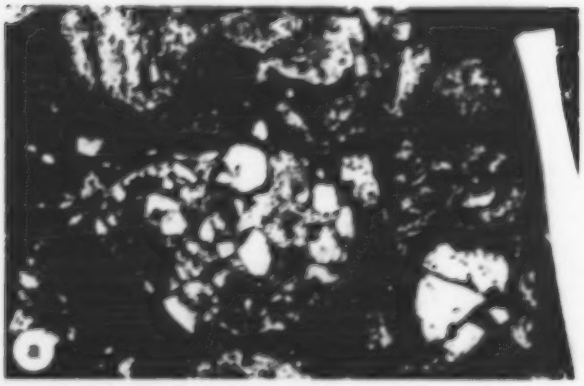
The red sandstone and shale member is at least 105 m thick and rests usually upon the unweathered granitic basement. The main lithology is orange- to pink-weathering fine-grained red sandstone to grit locally containing white quartz pebbles up to 5 cm in size. Sedimentary structures include plane lamination, which gives much of the exposure a flaggy appearance, as well as planar and trough crossbeds, linear wave-ripples and interference ripples. In the east the unit is clearly overlain by the quartz conglomerate (member 3), but in the west where member 3 is very thin and poorly exposed it is not possible to separate member 2 from the similar member 4. At least one well defined layer of red blocky desiccation-cracked mudstone is present in member 2. It contains 5-10 % of green reduced layers up to 15 cm thick.

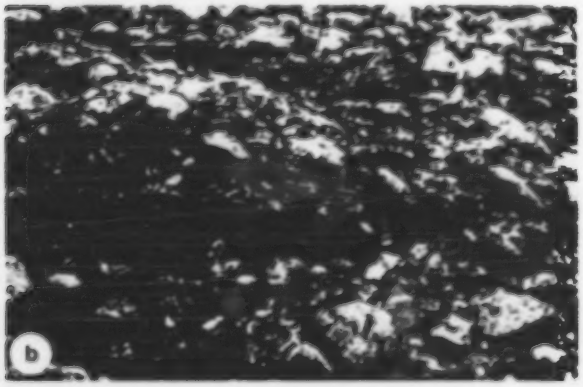
From 5 thin sections, the composition of the sandstone of member 2 ranges from poorly sorted and rounded polymict granule conglomerate and coarse sandstone with a large amount of granitic clasts and with hematite and hematized biotite in the matrix, to well sorted and moderately rounded, hematitic quartz-cemented quartz arenite. One sample taken from the above desiccation-cracked mudstone is a hematitic, very fine grained quartz arenite.

Member 3, quartz conglomerate

This member ranges from quartz grit with quartz pebbles to quartz-boulder orthoconglomerate. Where member 3 is thickest, in the eastern part of the area, the granitic basement is overlain by 15 m of red to orange sandstone of member 2, with planar crossbeds upto 60 cm thick and wave and current ripples. The sandstone is overlain by 6 m of quartz-pebble conglomerate, 12 m of red sandstone and conglomerate comprising member 3, followed by red sandstone.

Member thickness and grain size decrease westward. In the western part of the area exposure of member 3 is very sparse by the standard of the area and evidence of the unit usually consists of fragments in the drift. The westernmost exposure, 15 km east of Agu Bay, consists of quartzite containing white quartz pebbles 1 cm in size. In the central part of the area a maximum thickness of 3 m and a maximum grain size of 8 cm were recorded. The best exposure showed 15 m of red crossbedded sandstone and grit overlain by 3 m of quartz-pebble conglomerate with pebbles up to 5 cm in size, overlain in turn by 20 m of red shaly mudcracked siltstone containing wave-ripples of very fine grained sand.





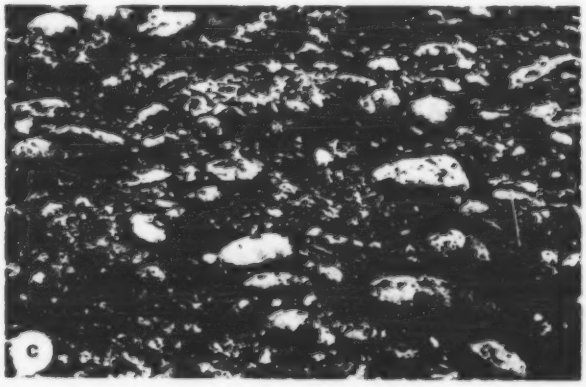


Figure 4. Quartz conglomerate (member 3), Nyeboe Formation. (a) Cobble of quartz pebbles from earlier sedimentary cycle, site C457 (GSC 203264-R). (b) Vertical view of imbrication of intermediate clast axes. Imbrication indicates sedimentary transport to northwest (azimuth 336°), pencil give scale, site 456 (GSC 203264-S). (c) Plan view of clasts of Figure 4b. Major axes are oriented athwart transport direction. (GSC 203264-T)

In the east, quartz cobbles are common and some quartz boulders in the member are up to 50 cm across. Clasts are nearly all of white quartz and are well sorted and rounded. Brief examination of some large exposures shows clasts of quartzite, banded iron formation, jasper, quartz pebble-bearing quartzite and quartz-pebble conglomerate (Fig. 4a). The clasts have well developed solution pits (cf. Pettijohn, 1975, p. 64). No paraconglomerates were seen in the member.

The quartz-pebble orthoconglomerate beds within the lower redbed member have a range of fabric development, in part due to different clast sphericity among the exposures. Where clast fabric was not clear, orientation of the long axis of a number of clasts was measured in bedding-surface exposure and the imbrication of the fabric noted in vertical exposure. In some outcrops with strongly blade-shaped clasts the fabric was obvious and a statistical method was not needed (Fig. 4b, c).

Clast fabric in undeformed conglomerates is useful in deciphering paleocurrent direction and depositional environment (Collinson and Thompson, 1982, p. 116). Clast fabrics such as those found in member 3 can be formed by rolling of clasts by a current on a river bed.

To form such fabrics the clasts come to rest with their long axis (a) athwart the current (a_t) and the intermediate axis (b) dipping upstream (b_i). This type of fabric the "$a_t b_i$" type is most stable with respect to the river current and indicates the depositional environment and the direction of flow of the depositing current. Although beach conglomerates can be imbricate, the clasts tend to be either very steeply inclined and appear to lack consistent orientation about the vertical axis, as in the case of the "edgewise breccia" (Ricketts and Donaldson, 1979), or imbricated at a lower angle (2-15°, Pettijohn, 1975, p. 68) than the Nyeboe Formation clasts.

Two obvious $a_t b_i$ fabrics, seen by inspection of the ouctrop (Fig. 4b, c) indicate flow to the north and northwest respectively. At two other localities fabrics which required measurement of 50 and 100 clast orientations respectively, indicated eastward and northwestward transport. In measuring these two fabrics only clasts in contact with other clasts less than half their size were measured to minimize interference in the fabric from roughness in the stream bed.

Interbedded with the imbricate conglomerate is pebbly grit and sandstone containing wave and current ripples and planar and trough crossbeds. One linguoid current ripple from the sandstone indicated transport to azimuth 300°. Three trough crossbeds indicated transport to azimuths 299, 308 and 324°. Taken together these sparse paleocurrent data from member 3 in the eastern part of the area, hint at northwestward transport (Fig. 5).

Members 4 and 7, red sandstone and shale

Because of poor exposure it is not possible clearly to define the stratigraphy of members 4 and 7, the redbeds that lie between member 3 and the Sikosak Bay Formation (see Fig. 3). In the central part of the area at site C12 a 6 m section of red shaly siltstone directly overlies 1-3 m of quartz-pebble conglomerate, presumably of member 3. It contains grit-sized grains and 10% of reduced layers up to 15 cm thick, mudcracks and rare wave ripples. Exposures stratigraphically higher include 1 m of red grit overlain by 20 m of red siltstone with reduced zones similar to those already mentioned. Other exposures of members 4 and 7 consist of flaggy tan sandstone red siltstone and shale. Fragments of mudcracked and rippled red siltstone were found in the drift overlying these units.

At the eastern limit of the area there is a simpler stratigraphy in the upper part of the Nyeboe Formation inasmuch as only pink and red sandstone and grit intervene between the well developed quartz-pebble conglomerate, member 3, and the overlying Sikosak Bay Formation.

Member 5, dolomitic quartz arenite and stromatolitic dolomite

Where best exposed (C31, C476) member 5 consists of 6 m of irregularly-laminated flaggy dolomite overlying 6 m of red sandstone that contains rare beds, 30 cm thick of dolomite. The member is overlain in turn by 50 m of fissile, fine grained, planar-crossbedded sandstone with rare dolomite beds and by at least 30 m of dark red crossbedded sandstone and grit of member 7, member 6 presumably being absent this far east.

Another section of member 5 is 20 m thick and contains 3 thick cycles of lustre-mottled dolomitic sandstone with wave ripples and about 10% of pale pink sandstone beds. The member passes upward gradationally to sandstone with increasing amounts of sand beds and crossbedding.

A few exposures of the member contain opposed crossbeds on a scale of 5-30 cm; other outcrops contain columnar and wavy low domal stromatolites and isolated stromatolite buns.

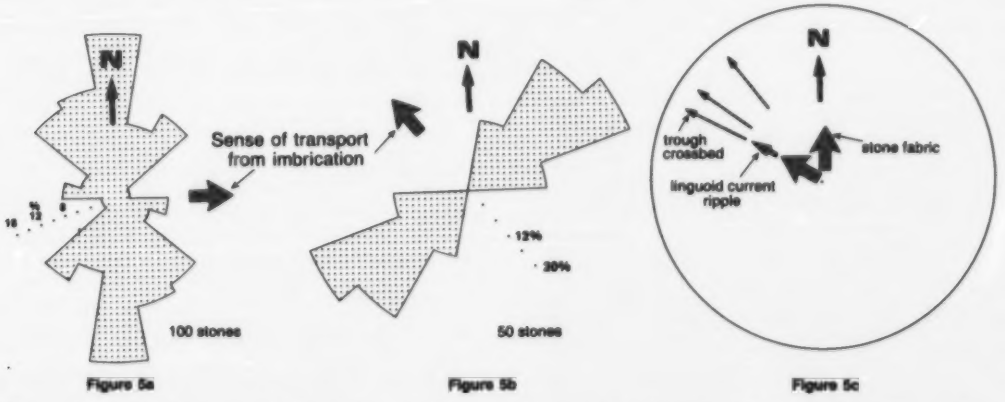


Figure 5a Figure 5b Figure 5c

Figure 5. Paleocurrent indicators, quartz conglomerate (member 3), Nyeboe Formation. (a, b) Fabrics from clast major axes, plan section. (c) Paleocurrent directions from obvious imbricate clast fabrics and from structures in interbedded sandstone.

Some of the dolomitic sandstone of member 5, can be seen in thin section to consist of well sorted red arenite containing about equal proportions of quartz grains and oolites. The quartz grains are well rounded and the oolites show both radial and concentric internal structure, and some are cored by quartz grains. The grain size is in the coarse sand range. Most sandstones are extensively recrystallized and consist of quartz grains floating in a cement of sparitic carbonate. Original presence of oolite is suggested by curved hematite dust trains transecting groups of sparite crystals.

Member 6, altered basalt

Commonly amygdaloidal, red and purple oxidized basalt flows of member 6, the altered basalt, occur within the Nyeboe Formation about 100 m above the granitic basement (Fig. 6). The flows occur at approximately the same stratigraphic level as member 5, the latter being found in outcrop both above and below the flows.

The eastward-thinning basalt is intermittently exposed over a strike length of 61 km east from the east shore of Agu Bay to north of Whyte Inlet. Four kilometres east of Agu Bay the basalt is about 10 m thick. Thirty eight kilometres east of the bay where strata dip very gently to the south, three separate bluffs of red basalt 6, 3, and 3 m high, in ascending order, occur over a north-south horizontal distance of 150 m. Separated by hard dark pink quartzite they probably represent three separate flow units. Fifty-one kilometres east from Agu Bay the unit is 1-3 m thick and columnar stromatolites are present in nearby red dolomitic siltstone rubble probably of member 6. Seventy kilometres east from Agu Bay aphanitic red basalt debris with green amygdules was found in the felsenmeer associated with blocks of red to rusty dolomitic sandstone. Association with dolomitic blocks, probably to member 6 suggests that the basalt extends at least 70 km east from Agu Bay. To the east of this no evidence of the altered basalt unit was found. Three chemical analyses from the unit are given in Table 1. According to W.R.A. Baragar (personal communication, 1985), because the rocks are highly altered, the overall analyses are unreliable. TiO_2, however, is consistently low for most plateau basalts, but is consistent with values in an ocean-opening setting such as the present Baffin Bay. High MgO, which may not be reliable, and high Cr fit with the low TiO_2 content.

Sikosak Bay Formation

This formation is named after Sikosak Bay which lies on the north shore of Fury and Hecla Strait, at longitude 83°50'. It consists of white to light pink, rarely purple, quartz arenite that forms fairly easily mappable ridges and north-facing cliffs, 15-30 m high and rarely up to 150 m, in the centre of the area where capped by basalt of the Hansen Formation.

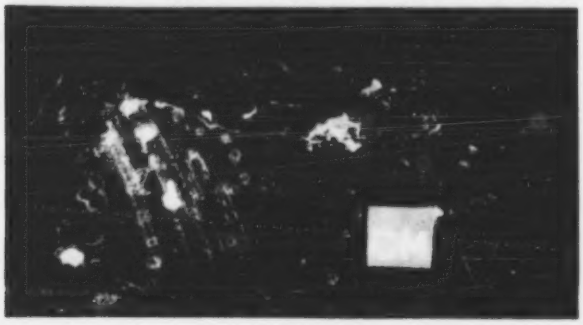


Figure 6. Typical red basalt with white and green amygdules, altered basalt member, Nyeboe Formation, sawn hand specimen, patch is 1 cm wide. (GSC 203902-Y)

Westward the basalt occurs increasingly lower in the quartzite until near Agu Bay it is found at the base, indicating the diachronous nature of the quartzite (see below).

In the east the Sikosak Bay Formation appears to overlie the quartz-clast conglomerate, member 3, of the Nyeboe Formation directly, due to eastward pinch-out of shaly, dolomitic and basaltic members in the latter formation. Because of eastward pinch out of succeeding stromatolitic Dolomite and Black Shale members of the Agu Bay Formation and absence of the Hansen Formation (Fig. 3) the Sikosak Bay Formation is overlain by red siltstone at the base of the Redbed Member of the Agu Bay Formation at the eastern limit of the area.

In the central part of the area the Sikosak Bay Formation is underlain by poorly exposed red sandstone and shale of the upper part of the Nyeboe Formation. In a stream gorge site C461 (see centre column, Fig. 3), the unit is overlain in sequence by 5 m of drift, several metres of red mudcracked shale, and the stromatolitic Dolomite Member of the Agu Bay Formation. Exposure in a north-facing cliff 38 km to the west, site C382, shows that the Dolomite Member is missing and the quartzite is overlain by the Black Shale Member.

In the western part of the area the Sikosak Bay Formation is underlain by the Hansen Formation and appears overlain by the finer grained basal part of the Redbed Member of the Agu Bay Formation. Presence of black shale fragments locally in the drift at the top of the Sikosak Bay Formation suggests the presence of the Black Shale Member beneath the Redbed Member.

The Sikosak Bay Formation appears massive in many exposures but locally can be flaggy, with 1-2 cm thick rippled beds. Linear to undulose, symmetrical to asymetrical wave ripples are a common ripple type. Both trough and planar crossbeds are also present. In two exposures two examples of herringbone, crossbeds, one with a set thickness of 3 cm, were found. Thirteen trough crossbeds (Fig. 7a) suggest transport to the southwest. The more or less north-south orientation of wave ripples crests (Fig. 7b) could indicate a north-south aligned shoreline or shallow sand body. The quartzite is generally medium-to fine-grained and rarely of grit size. In only one exposure were quartz pebbles, commonly 2-2.5 cm in size, rarely upto 10 cm, found. Shaly and silty beds are absent.

Five thin sections show the unit to be a very pure quartz-cemented quartz arenite with varied sorting and generally high rounding (Fig. 8). Some intergrain pores are sealed with sericite, well crystallized hematite plates and books of a phyllosilicate with dull grey birefringence, probably kaolinite. Heavy minerals include rare rounded zircon, tourmaline, other unidentified transparent grains and opaque laths of hematite, possibly after biotite, as well as very rare altered mica flakes and patches of a well crystallized TiO_2 mineral.

Hansen Formation

This basaltic formation can be traced eastward 93 km, from the east shore of Agu Bay as well developed north-facing cuestas (Fig. 9a) characterized by columnar jointing (Fig. 9b). The Formation is named after Cape Godfred Hansen, on the west side of Agu Bay. East of this it was shown to be absent in an area of good outcrop. Therefore the unit extends about 30 km more to the east than does the basalt unit in the Nyeboe Formation. Thickness estimates are generally not possible due to heavy mantling of cuesta scarp faces by talus, but 32 km east of Agu Bay a thickness of 30 m was recorded.

Table 1. Chemical analyses of basalt flows within, and mafic intrusive rocks cutting, the Fury and Hecla Group. Columns 1-4, altered basalt unit, Nyeboe Formation, columns 5-8, Hansen Formation, columns 9, 10, Dybbol Sill within Autridge Formation, columns 11-14 dykes cutting all other units. Sample locations on Figure 2 (map, in pocket).

column	C4B (1)	C407 (2)	C406C (3)	C433 (4)	L12 (5)	Z2 (6)	Z335 (7)	C337 (8)	Z257 (9)	Z218A (10)	C25 (11)	C60 (12)	C145 (13)	Z212 (14)
SiO_2	47.1	48.5	46.9	38.3	55.3	45.1	49.9	50.4	49.6	48.8	58.2	49.6	50.2	50.6
TiO_2	0.97	0.89	0.88	0.94	1.05	1.01	1.22	1.28	0.86	1.24	1.58	2.20	1.37	1.09
Al_2O_3	13.4	14.3	14.5	14.8	14.3	14.9	14.4	13.1	16.0	13.1	14.8	17.0	17.7	17.0
Cr_2O_3				0.05					0.06	0.05				
Fe_2O_3	14.2	8.7	8.3	10.6	4.2	4.0	4.2	3.9	0.9	0.8	2.7	3.4	2.7	3.1
FeO	0.5	1.4	1.4	2.6	4.4	9.4	7.9	6.9	8.4	11.6	6.4	10.0	8.3	6.9
MnO	0.08	0.03	0.05	0.15	0.04	0.04	0.20	0.12	0.16	0.22	0.08	0.20	0.20	0.19
MgO	8.27	13.4	13.1	12.3	9.77	14.9	5.82	7.44	7.65	8.59	3.99	3.52	5.20	5.97
CaO	3.47	0.38	0.35	3.45	3.20	0.26	7.05	8.09	13.7	11.9	1.45	10.0	11.0	11.6
Na_2O	0.4	0.0	0.0	0.0	1.3	0.4	1.5	1.1	1.0	1.4	2.1	2.3	2.2	2.2
K_2O	3.92	5.22	7.44	6.00	1.44	1.19	3.39	0.81	0.21	0.33	4.97	0.41	0.54	0.42
H_2OT	4.1	6.2	6.4	5.2	5.0	7.8	2.8	3.3	0.6	1.0	2.8	1.0	1.0	1.2
CO_2	3.9	0.2	0.2	4.6	0.2	0.1	0.1	2.1	0.1	0.3	0.1	0.0	0.0	0.1
P_2O_5	0.12	0.14	0.11	0.16	0.11	0.09	0.09	0.10	0.06	0.09	0.40	0.17	0.09	0.07
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ba	0.042	0.061	0.05	0.077	0.21	0.015	0.043	0.015	0.006	0.010	0.097	0.007	0.015	0.015
Rb	0.005	0.007	0.007	0.005	0.000	0.000	0.004	0.000	0.000	0.000	0.05	0.000	0.000	0.000
Zn	0.001	0.001	0.000	0.002	0.002	0.002	0.009	0.007	0.006	0.010	0.007	0.008	0.009	0.008
Total	100.48	99.43	99.69	99.23	100.52	99.21	98.63	98.66	99.31	99.44	99.73	99.82	100.52	100.46
Ag	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050
As	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20
B	0.0075	< 0.0050	0.012	0.011	0.0064	< 0.0050	0.0058	< 0.0050	< 0.0050	< 0.0050	0.0061	< 0.0050	< 0.0050	< 0.0050
Ba	0.043	0.057	0.049	0.070	0.020	0.015	0.040	0.016	0.0050	0.0090	0.92	0.0067	0.014	0.015
Be	< 0.00030	< 0.00030	< 0.00030	< 0.00030	< 0.00030	< 0.00030	< 0.00030	< 0.00030	< 0.00030	< 0.00030	< 0.00030	< 0.00030	< 0.00030	< 0.00030
Ce	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020
Co	0.0028	0.0031	0.0028	0.0039	0.0028	0.0039	0.0034	0.0040	0.0033	0.0051	0.0021	0.0040	0.0040	0.0034
Cr	0.023	0.25	0.022	0.021	0.015	0.019	0.0035	0.0036	0.036	0.030	0.0019	0.0033	0.0073	0.012
Cu	0.0087	0.0012	0.0012	0.0021	0.0028	0.0025	0.028	0.015	0.11	0.014	0.0023	0.028	0.018	0.010
La	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Mo	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050
Ni	0.0078	0.0078	0.0074	0.011	0.0088	0.0087	0.0045	0.0054	0.013	0.017	0.0015	0.0044	0.0039	0.0073
Pb	< 0.07	< 0.070	0.070	< 0.070	< 0.070	< 0.070	< 0.070	< 0.070	< 0.070	< 0.070	< 0.070	< 0.070	< 0.070	< 0.070
Sb	< 0.50	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Sn	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020
Sr	0.0048	0.0034	0.0034	0.0048	0.0085	0.0018	0.015	0.012	0.012	0.012	0.014	0.019	0.020	0.017
V	0.026	0.020	0.021	0.014	0.025	0.027	0.032	0.034	0.028	0.035	0.012	0.041	0.032	0.029
Y	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040
Yb	0.00042	0.00044	< 0.00040	< 0.00040	0.00045	< 0.00040	< 0.00040	< 0.00045	< 0.00040	< 0.00044	0.00060	< 0.00040	0.00041	< 0.00040
Zn	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020
Zr	0.13	0.11	0.011	0.0099	0.0081	0.0082	0.0072	0.0084	0.0055	0.0064	0.047	0.0084	0.0053	0.0081

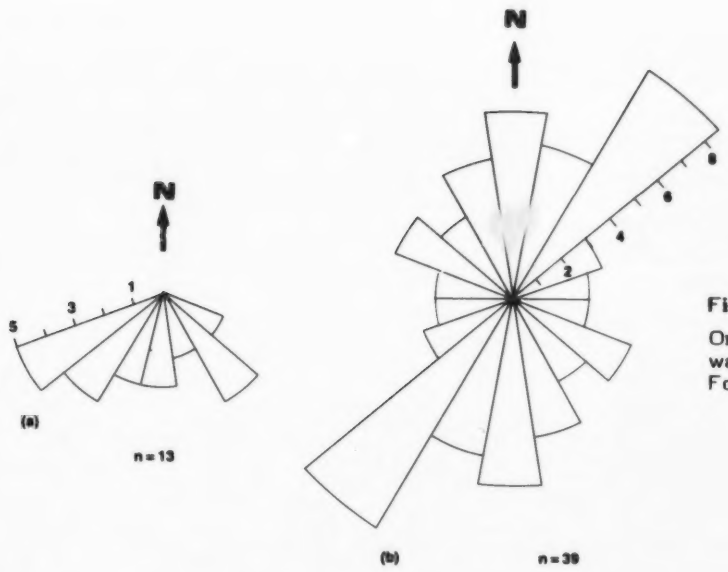


Figure 7

Orientation of (a) trough crossbeds and (b) wave-ripple crests, Sikosak Bay Formation. See text for discussion.

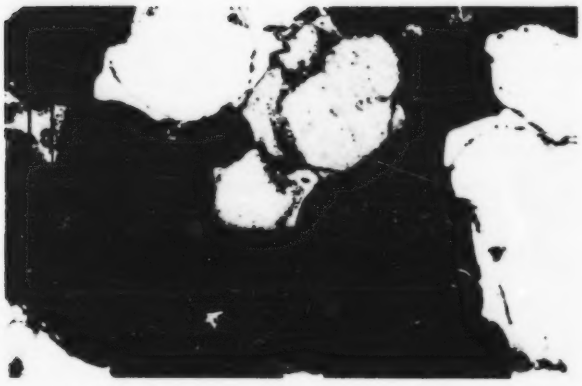


Figure 8. Texture of quartz-cemented quartz arenite, Sikosak Bay Formation. Photomicrograph with crossed nicols. Hematite dust trains show high rounding of detrital grains. Grain "A" is 0.25 mm across. (GSC 203901-T)

Unlike the red, oxidized basalt of the Nyeboe Formation, this unit is grey green to black on freshly broken surfaces, a difference reflected in its ferric/ferrous ratio of 0.5-1.0, compared with 7.0 for the oxidized basalt of the Nyeboe Formation (Table 1). Weathered surfaces are rusty brown and the columnar top of the unit was reddened.

Owing to poor outcrop almost no exposures of the top and base of the unit were seen. At one locality where it overlies the Sikosak Bay Formation, altered and rounded bodies of similar quartzite are present in the basalt suggesting that the quartzite was unlithified during its incorporation. At another location the upper 4 m of a 10 m cliff of the upper unit are amygdaloidal.

The writer is confident that the Hansen Formation overlies the Sikosak Bay Formation east of Whyte Inlet. Between the longitude of Whyte Inlet and that of the mouth of Autridge Bay the Sikosak Bay Formation underlies the Hansen. No quartzite of Sikosak Bay type was seen to overlie the Hansen in poorly exposed ground. Farther west, the Sikosak Bay Formation clearly overlies the Hansen, but small exposures of similar quartzite occur beneath the Hansen. It was often not possible to tell whether these small exposures were bleached outcrops of the Agu Bay Formation or of Sikosak Bay type.

The writer therefore concluded that the stratigraphic position of the Hansen Formation rises eastward from near the base to the top of the Sikosak Bay Formation, suggesting diachronous sedimentation of the latter (see below). It should be borne in mind however that the field evidence supporting origin as flows rather than a sill is less than convincing. If the latter origin were applicable, there would be no argument for a diachronous Sikosak Bay Formation.

The generally high Fe^{+3}/Fe^{+2} ratios (0.5-1.0) of the Hansen Formation (Table 1) indicate, almost certainly, that the formation is subaerial basalt flows rather than a sill or submarine flows (Fe^{+3}/Fe^{+2} = 0.2-0.3). As with the basalt (member 6) of the Nyeboe Formation, low TiO_2 and generally high MgO and range of Zr fit with extrusion close to an initial ocean opening (W.R.A. Baragar, personal communication, 1985), a conclusion also reached by Galley et al. (1983).

Agu Bay Formation

This formation is named after a bay at the west margin of the map area at longitude 86°40'. A local thin basal stromatolitic Dolomite Member, a Black Shale Member and an overlying Redbed Member are designated as formal members of the proposed Agu Bay Formation. Toward the east both the Dolomite Member and the Black Shale Member pinch out and the Redbed Member becomes increasingly arenaceous.

Dolomite Member

This stromatolitic dolomite member is intermittently exposed above the Sikosak Bay Formation. It was found to be best exposed in a stream valley at site C461 and is mainly traceable across the area by means of blocks found in the drift from 3 km east of Agu Bay, at the western edge of the area, to 12 km east of site C461. Twenty seven kilometres east of site C461 Sikosak Bay Formation is overlain directly by the Redbed Member, both the stromatolitic Dolomite Member and the Black Shale Member being absent. Nowhere east of this sections was stromatolitic dolomite found in the drift.

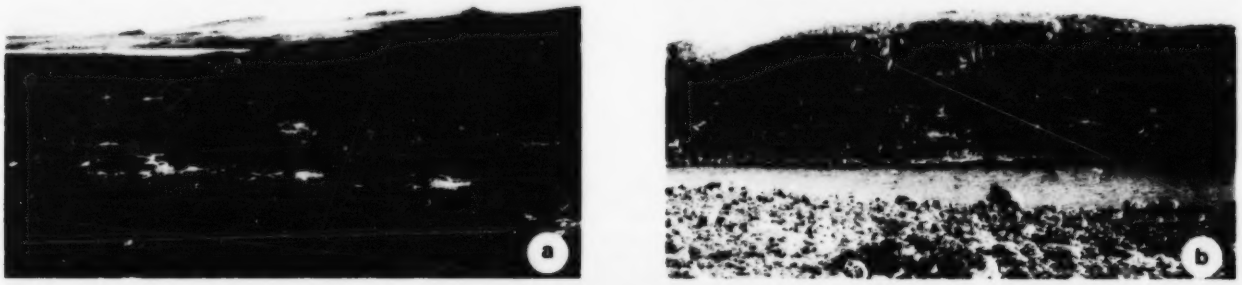


Figure 9. Hansen Formation. (a) Cuesta form of typical exposures (GSC 203901-K). (b) Scarp face of cuesta shows columnar-jointed basalt overlying horizontally layered Sikosak Bay Formation above lake. (GSC 203901-F)

That the Dolomite Member is not continuous is shown from a well exposed north-facing cliff at site C382, 21 km west of site C461. Here the Sikosak Bay Formation is directly overlain by the Black Shale Member. Upward coarsening sandstone units in the Black Shale Member, exposed in this cliff (see Fig. 11e) contain grains composed of stromatolitic material with filament moulds similar to samples taken from stromatolite domes at site C461.

A detailed account of the internal stratigraphy of the member at site C461 is given below to illustrate its complexity and more importantly to record the data base from which sedimentary interpretation has been made. A composite section from site C461 consists of the following units:

(Top) unit

9. 15 m of black shale, the lower part of the Black Shale Member
8. 0.5 m of interbedded black shale and black dolomite
7. 1 m of black shale
6. isolated stromatolite reefs (see Fig. 10b) within clastic sediments, consisting of oolites, oncolites and crossbedded carbonate grainstone
5. 1.5 m of dolomite grainstone with truncated stromatolites (Fig. 10a) and oncolites
4. 30 cm of grey shale with mudcracks at the top
3. 3 m of drift
2. 3 m of grey laminated calcareous mudstone

(base)

1. 2 m of drift overlying the Sikosak Bay Formation

Some further details of the section are as follow:

A set of sand waves (Fig. 10c) at the base of unit 5 has a wavelength of 1 m. Its asymmetry indicates transport to aximuth 244°. Mudcracks occur in siltstone in the inter-wave troughs. Associated wave ripples with a wavelength of 25 cm have crests oriented along azimuths 069 and 155°. Unit 5 is strongly recrystallized, and contains remnants of 0.5 mm oolites, rounded and angular quartz grains, oncolites and fragments of abraded stromatolite laminae 5-10 mm across. Some stromatolites in unit 5 are planed off at the base of a grainstone layer at the top of the unit (Fig. 10a).

In unit 6 one patch, 30-60 cm high of a single layer of laterally linked hemispheroidal stromatolites formed on a linear ridge on the substrate. Other assemblages up to 5 m high consist of circular (Fig. 10d) to oval laterally linked domes up to 2.5 m long and oriented along azimuth 060°. These stromatolites contain desiccation cracks and some of them have an unusual atoll structure (Fig. 10e) in which a horizontally truncated planar centre is rimmed by a smooth wall. Vertical sections through the wall show that its core is composed of the truncated margin of a pre-existing dome, the central part of which has been removed. The remnant was later coated by laminae formed during a later phase of stromatolite growth (Fig. 10f).

Black Shale Member

This 75 m thick member conformably overlies the Dolomite Member, or where the latter is absent, the Sikosak Bay Formation, and is gradationally overlain by the Redbed Member. The Black Shale Member is present west of longitude 83°30' and may be present as far east as the eastern limit of the Hansen Formation at longitude 84°10'.

The member consists of friable black shale and siltstone with several per cent of laterally continuous (Fig. 11a) grey arenite beds up to 2 m thick and composed of quartz arenite or carbonate oolite and algal mat(?) fragments similar to that of the stromatolites of the underlying Dolomite Member.

Because of its fissile nature the member does not outcrop well. Only in two localities are complete sections exposed. One is a canyon with difficult access (site L22) where it is at least 60 m thick. The other is an easily accessible north-facing cliff (site C382) 16 km north of the tip of the peninsula enclosing Autridge Bay where a 76 m section was measured (Fig. 11b). The following detailed account of the member and the included sandstone beds is taken largely from site C382.

In the cliff the member directly lies conformably between the Sikosak Bay Formation and the overlying Redbed Member although presence of stromatolitic debris, mentioned above, may attest to nearby stromatolite reefs of the Dolomite Member. At site C382 the Black Shale Member consists of mainly black shale, some fissile and some interbedded, with grey- and buff-weathering siltstone. Red shale units are present at the base and in the middle of the unit (Fig. 11b).

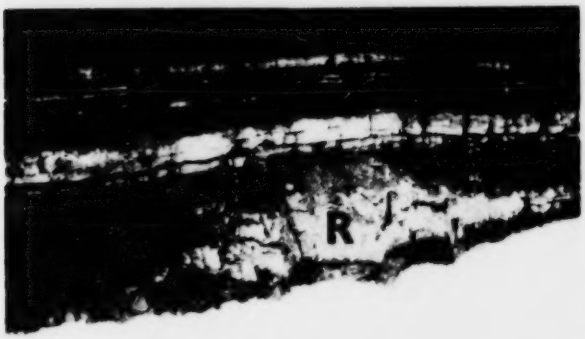
At the base of the Black Shale Member occur thin red sandstone and shale beds which farther east, downstream from site C461, are about 10 m thick. At site C382 the basal unit (unit 1) of the Black Shale Member (Fig. 11c) consists of (a) 60 cm of red fine grained sandstone and siltstone, (b) 50 cm of hematite and black (limonite?) stained sandstone that is crossbedded on a scale of 8 cm and (c) 5 m of black fissile shale containing 30 cm of dark red sandstone at the base.

Unit 2 (Fig. 11d) consists of black shale with interbeds, about 15 cm thick, of micaceous quartz-rich siltstone with varied amounts of carbonate matrix.

Figure 10. Dolomite Member, Aqu Bay Formation, site C461.

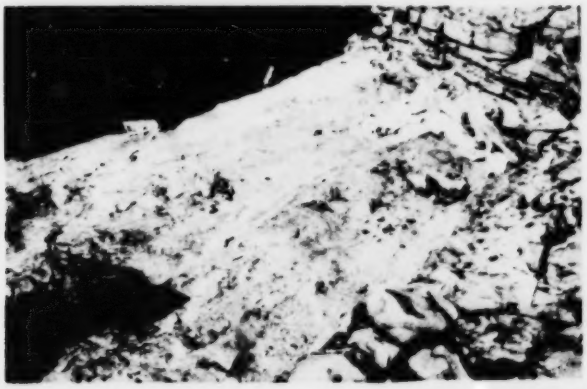
(a) Vertical section through stromatolite domes that have been eroded to planar surface (arrowed) and overlain by carbonate grainstone. (GSC 203901-J)

(d) Typical 30-60 cm high laterally linked stromatolite domes. (GSC 203901-C)

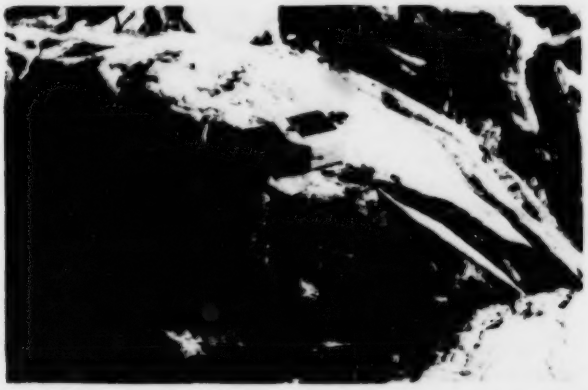


(b) Isolated stromatolite reef (R) several metres high, at cliff base in river gorge. (GSC 203901-E)

(e) Stromatolite domes with "atoll structure". (GSC 203901-G)

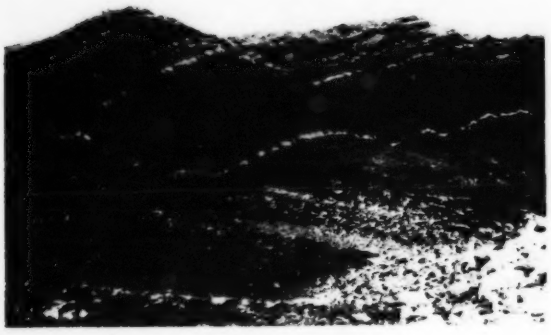


(c) Sand waves at base of member, direction of sediment transport toward upper left (244°), Brunton compass is at centre of figure. (GSC 203901-Z)

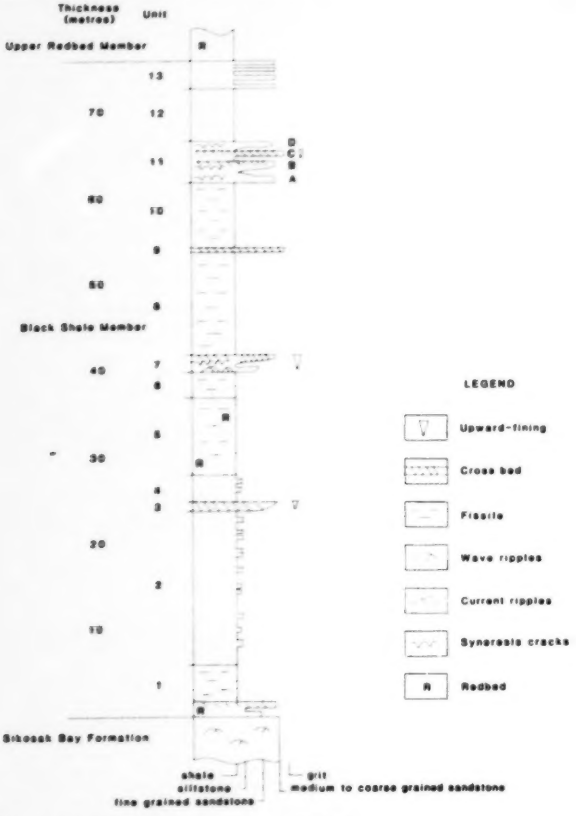


(f) Vertical section wall rimming "atoll structure", centre of dome is to left. Lamination of earlier phase of growth of dome is truncated, presumably during phase of erosion and inner part of dome has been removed. Laminae from later phase of growth blanket early laminae, covering them discordantly towards centre of dome. (see text; GSC 203901-M)

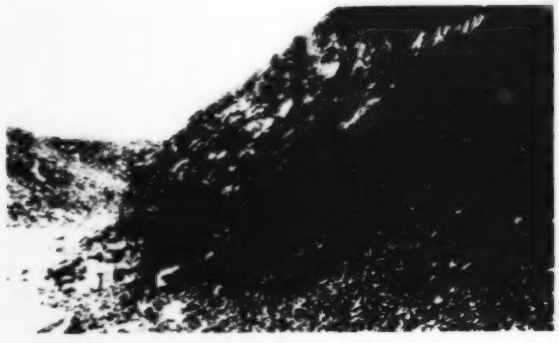
Figure 11. Black Shale Member, Aou Bay Formation, site C382



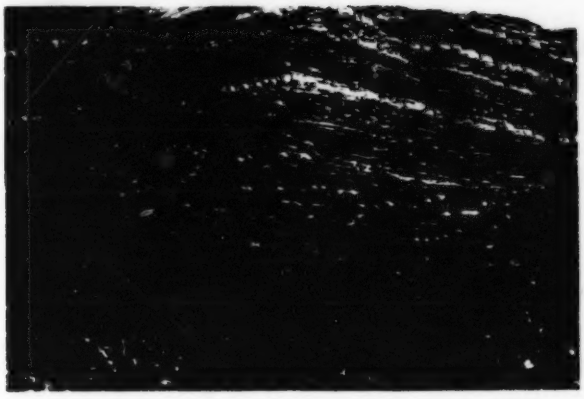
(a) General view. (GSC 203989-T)



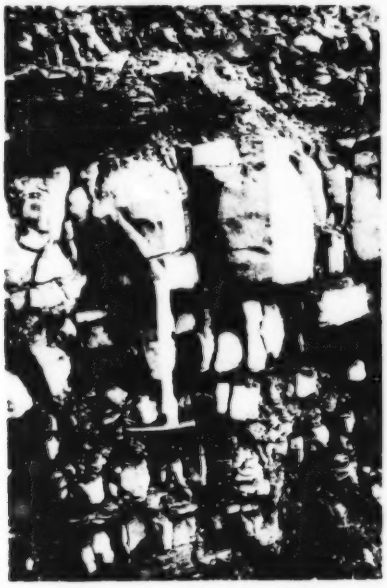
(b) Stratigraphic section (site C382).



(c) Base of unit 1, resistant sandstone beds protrude through talus of black shale and siltstone. (GSC 203901-D)



(d) Black shale with thin sandstone beds. (GSC 203989-S)



(e) Upward coarsening sandstone bed, with upward thickening crossbeds unit 3 (Fig. 11b). Grains include quartz, concentrically laminated oolite-like carbonate and fragments of stromatolite laminae. (GSC 203901-X)

(f) Upward coarsening sandstone bed with upward-thickening crossbeds, unit 7 (Fig. 11b; GSC 203901-U).

Unit 3 is the lowest of several extensive crossbedded sandstone units of even thickness in the black shale unit (Fig. 11e). Its coarseness and bedding scale increase upward from 8 to 30 cm with 1 to 3 cm partings of shale. At the top of the unit the grain size is 2 mm and the sandstone contains shale chips and crossbeds. Grains consist of replaced oolite-like sparite with remnant skins, quartz grains, some well-rounded fragments of stromatolite laminae with filament moulds like those seen in the domal stromatolites of the stromatolitic dolomite member, all set in a sparitic matrix.

Unit 4 consists of 3 m of black shale similar to unit 2, unit 5 of 9 m of red fissile shale, and unit 6 of 3 m of black shale.

Unit 7, the second extensive sandstone, consists of 30 cm of lenticular and wavy bedded rippled sandstone with black shale drapes overlain in turn by 40 cm of black shale and 1 m of sandstone (Fig. 11f). This sandstone contains apparently multidirectional crossbeds with scale increasing upward to about 8 cm. It should be noted that many sandstone blocks at the base of the cliff section at site C382 contain abundant multidirectional crossbeds and syneresis cracks. The sandstone also contains shale chips and syneresis cracks in its lower half. Unit 8 is composed of 12 m of black fissile shale.

Unit 9 is a 15 cm thick crossbedded, poorly sorted but well rounded, quartz grit with shale chips and a few micritic carbonate clasts set in a sparitic cement. The unit has a sharp base and a wavy top. The undulations on the top have a amplitude of 6 cm and a wavelength of 40 cm, suggesting deposition of the unit as a migrating quartz sand wave. Unit 10 consists of 7.5 m of black fissile shale.

Unit 11, about 5 m thick, consists of a group of four grey sandstone beds, A-D, separated by black shale (Fig. 11b). The lowest bed, A, is 0.5 m thick, commences with 10 cm of grey sand and syneresis-cracked black shale interbedded on a 1 cm scale, followed by 30 cm of sandstone with shale chips, and then by 45 cm of lenticularly bedded sandstone and syneresis-cracked shale. The unit passes gradually up into shale. The second sand bed, B, has a 30 cm thick wavy to lenticularly bedded basal part with syneresis cracks throughout. It is followed by 1 m of 1-15 cm thick rippled and crossbedded sandstone with wavy rippled tops and separated by mud drapes. The rippled and crossbedded sands beds resemble large scale lenticular bedding. Bed B passes up abruptly to black shale. Sand bed C has an abrupt base and top, consists of a lower part, 22 cm thick, made up of fine grained rippled dark grey sandstone, some flat bedded, that contains shale fragments. The 45 cm thick upper part is a light grey ripple-topped crossbedded sandstone in which crossbeds are 2.5-5 cm thick. Quartz clasts 0.7 cm in size, a possible erosion lag deposit of pebbles, cap the sandstone. The fourth sand bed, D, in unit 11 has a 10 cm thick base transitional from the black shale that separates it from sand bed C. The basal part is transitional through syneresis-cracked sand ripples in shale to 10 cm of wavy bedded sand beds with mud chips at their bases and with shale beds, interbedded at a 1-3 cm scale. Forty five centimetres of sandstone, crossbedded on a 5-10 cm scale, follow then 10 cm of sediment similar to the 10 cm thick basal part.

Unit 12 consists of black shale, and unit 13 of several 0.5 m thick sand beds (Fig. 11a), not examined in detail but from a distance similar to the sand beds of unit 11. Unit 12 is overlain by red shale at the base of the Redbed Member.

Redbed Member

This unit extends across the area from Agu Bay to Sikosak Bay. Because it consists of a large-scale regressive hemicycle (Weller, 1960) that coarsens upward from mainly red shale to mainly friable red sandstone, and lies immediately north of a ridge of resistant quartzite, the overlying Whyte Inlet Formation, it underlies a belt of north-sloping low, wet red, clayey ground. In the southern half of the belt, frost-heaved blocks from the underlying sandstone beds give rise to parallel east-striking trains of blocks that reflect the underlying stratigraphy and from a distance give a striped appearance to the terrain.

Poor exposure prevented accurate measurement of the thickness of the member. Estimates calculated from widths of the belt underlain by drift from the member combined with local bedrock attitudes indicate a thickness of about 500 m across the area. From widths of the red swampy ground, that are underlain by the shaly lower part of the member, it appears that the lower part comprises half the member in the centre of the area, and is no more that 20 m thick in the eastern part of the area. Canyon sections in the central part of the area (sites C382, C463) show a more or less linear increase in the sand-shale ratio up through the member.

Observations from scattered exposures show that the Redbed Member consists of hemicycles on three scales. The member itself is an upward coarsening cycle (megacycle) about 500 m thick. Superimposed on this, are numerous similar but 10-15 m thick cycles (mesocycles). Within the mesocycles are found about 15 cm thick upward-fining sandstone cycles (minicycles).

The Redbed Member conformably overlies the Black Shale Member, and the lower part is composed of red shale and siltstone with a minor amount of red sandstone beds. Black shale debris in the drift overlying the lower shaly part of the Redbed Member suggests the presence of this lithology. The sandstone-shale ratio increases upward (Fig. 12a) until the member is composed almost entirely of friable red sandstone, capped by several metres of hard, shiny, mudcracked, platy-fracturing red shale. This shiny shale serves as a marker bed in a sequence in which vertical lithological variation is subtle. Above the red shiny shale, transition to the overlying Whyte Inlet Formation quartz arenite occurs through some tens of metres of interbedded friable bright red sandstone and hard pink quartzite.

Mudcracks occur throughout the lower, red shaly part of the member. In the western part of the area, mudcracked shale is present in the drift overlying locations half way up through the member. Sandstone beds are abundantly crossbedded on a scale of 10 cm and contain many wave-ripples.

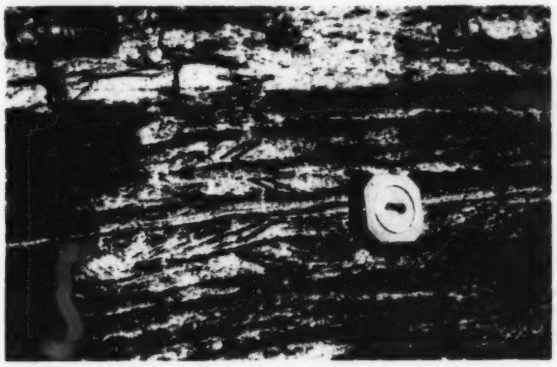
A loose sandstone block from the middle of the member showed a 1.5 m vertical extent of 4-10 cm thick crossbeds containing red mud chips and separated by suncracked mud films. From vertical faces on the block, at right angles to each other, the crossbeds appeared to be planar and opposed (Fig. 12b). Many other loose blocks of sandstone from the member contain small-scale crossbeds separated vertically by suncracked mudstone films.

An illustration of the upper part of the member is given by Figure 12a in which the rock consists of mesocycles of red sandstone, 70%, and red mudstone, 30%, alternating on a scale of about 10-15 m. Within the sandstone beds shown in Figure 12a occur upward-fining minicycles below 30 cm in thickness passing up from west-transported 5-10 cm high crossbeds indicating westward transport, through laminated and rippled siltstone and terminating in suncracked mudstone.

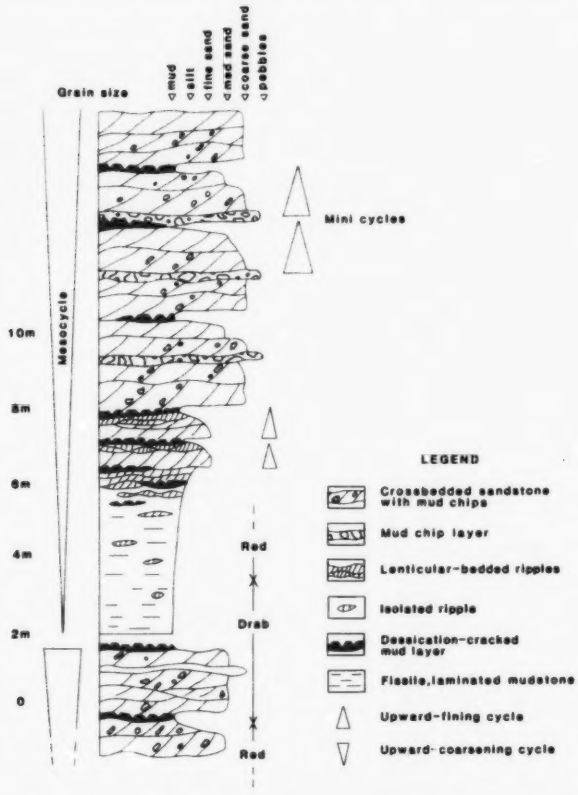
In well exposed hillslopes southwest of site C508 it was seen that the striped terrain mentioned above is caused by the 10-15 m scale shale-sandstone upward-coarsening mesocycles. Black shale fragments in the drift overlying the basal part of the shale show that even high in the member, cycles commence with black shale.

Figure 12. Redbed Member, Agu Bay Formation

(a) Upward-coarsening red mudstone-sandstone mesocycles, upper part of member. Cycles are about 15 m thick, site C463. (GSC 203901-Y)



(b) Vertical section of red quartz arenite with small-scale opposed crossbeds and mud chips (dark), upper sandy part of mesocycle. See Figure 12a. (GSC 203901-Z)



(c) Upward-coarsening mudstone-sandstone mesocycle. Note superimposed lower-order upward-fining hemicycles (minicycles), site C508 (for description see text).

(d) Part of upward-coarsening mesocycle shown in Figure 12c showing transition between mudstone and sandstone parts of cycle. Lithology is upward-coarsening red mudstone-siltstone with mudcracks in the upper part, hammer handle (white) shows scale. Site C508. (GSC 203989-B)

(e) Plan view of mud chip layer, probably formed from erosion of desiccation-cracked mudstone layer, sandstone part of upward-coarsening mesocycle. (GSC 203901-S)

A composite upward-coarsening mesocycle (Fig. 12c) can be reconstructed from parts of two cycles exposed in a stream gorge at site C508. The top of the underlying cycle, 1.5 m of medium grained grey sandstone, contains 5-10 cm thick crossbeds, wave ripples and, at its top, mudcracks. Rusty weathering, increasing upward through the sandstone, suggests weathering of pyrite produced diagenetically by a reducing influence from the overlying black shale.

After a covered interval of 30 cm, the mesocycle commences with 1.5 m of laminated black fissile shale that contains very small, isolated, silt ripples, but no mudcracks. The shale is overlain by 3 m of upward-coarsening red mudstone-siltstone (Fig. 12d) in which the isolated silt ripples coarsen, become larger and coalesce into lenticular beds and bed sets. Mudcracks occur only in the upper half of the red mudstone-siltstone.

This unit is overlain by 1.5 m of upward-coarsening, generally fine grained red sandstone, made up of 15 cm thick, upward-fining, cycles (minicycles) consisting of three parts, (a) a basal part with one- to several sets of trough crossbedded sandstone, 5-10 cm thick with uneven lenticular bedding, (b) a middle part of rippled fine grained sand, and (c) an upper part of red discontinuous desiccation-cracked mudstone films. The mudstone film layer is not always present. These small upward-fining cycles are similar to those described from loose blocks from the upper redbed member described above.

Succeeding the 1.5 m of upward-coarsening sandstone lie 8 m of red medium- to coarse-grained sandstone, also arranged in upward-fining cycles, but of coarser material and of larger scale. In the these coarser minicycles, sets of 5-10 cm thick trough and planar crossbeds contain mud chips in their foreset laminae and may also overlie mud chip layers (Fig. 12e), presumably formed from brecciated desiccation-cracked mud layers.

Crossbeds from site C508, n = 9 (to azimuth 180, 243, 292, 259, 219, 238, 250, 212, and 2090) show sand transport to the southwest, a direction similar to that derived from 20 trough crossbeds measured on a hill slope about 200 m southwest. Some of the crossbedded layers were overlain by desiccation-cracked mud layers. Although the top of the 8 m thick sandstone unit was not seen, observations elsewhere in the member suggest that it is overlain abruptly by black or red shale.

Thus, limited evidence from scattered exposure of the Redbed Member shows that it comprises an upward-coarsening megacycle about 500 m thick. Within this larger scale hemicycle are similar smaller scale hemicycles

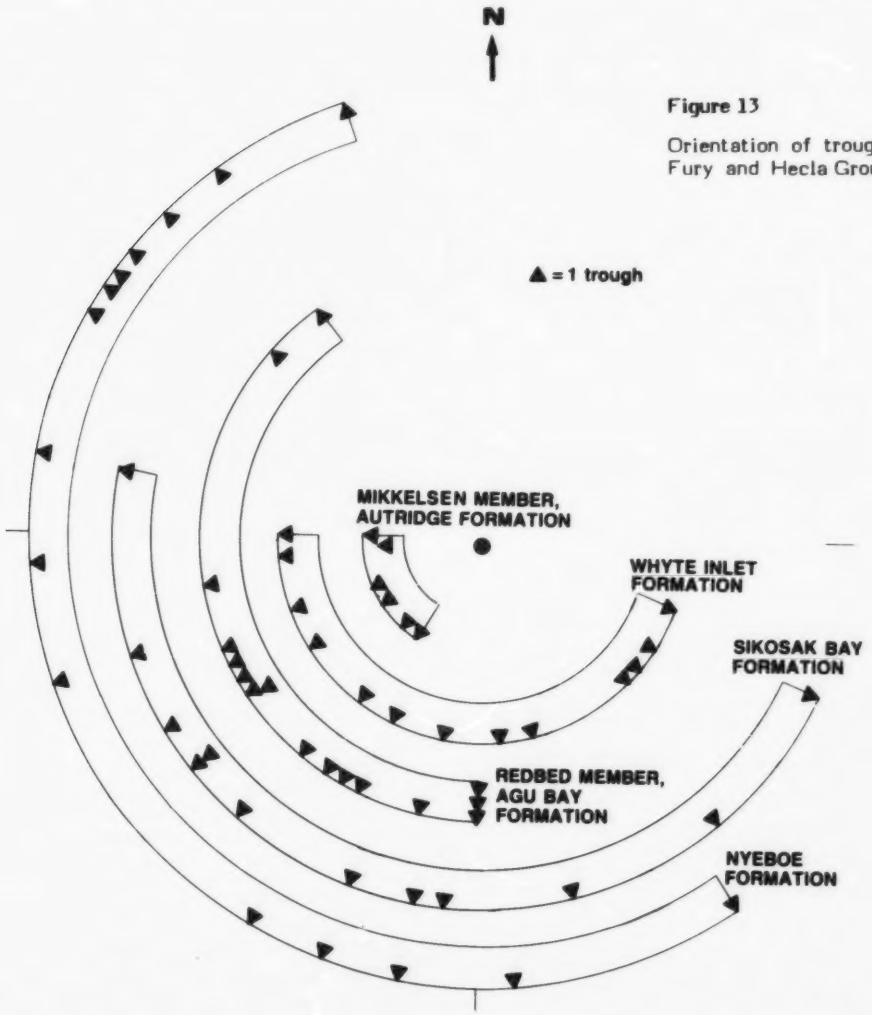


Figure 13

Orientation of trough-crossbeds Fury and Hecla Group.

(mesocycles) about 10-20 m thick. Within the upper sand part of the mesocycles are third order cycles (minicycles). In this case, upward fining instead of coarsening. The significance of these nested cycles is discussed below, under sedimentological interpretation.

Whyte Inlet Formation

This resistant formation forms a range of hills up to 600 m high that stretches east-west across the map area and comprises half the outcrop area of the Fury and Hecla Group. The hills overlook the head of Whyte Inlet on the north shore of Fury and Hecla Strait at longitude 84°50'. In the eastern part of the area studied the formation is at least 2 km thick and in the central part at least 3 km in thickness are exposed. In both cases the top of the formation is hidden beneath Fury and Hecla Strait, that lies to the south. Three kilometres east of Agu Bay, at the eastern limit of map area, the formation is much thinner, being represented only by some tens of metres of interbedded pink quartzite and red sandstone similar to its transitional base in the east.

In the east, the base of the formation consists of interbedded red friable crossbedded and wave-rippled sandstone and pink quartzite. Where the top of the formation is visible, that is, largely west of Autridge Bay, it passes up transitionally to the Autridge Formation through drab sandstone and varicoloured shale and siltstone. Near the top of the Whyte Inlet Formation, north of the east part of Autridge Bay a unit is present that is similar to the Mikkelsen (lower) Member of the Autridge Formation, except that it contains red sandstone and is overlain by quartzite similar to that of the Whyte Inlet Formation. Poor exposure prevents estimation if its thickness or relation to the Whyte Inlet Formation.

The bulk of the Whyte Inlet Formation consists of white- to purple, generally pink quartz, arenite of fine sand to grit size. Layers of pebbles up to 3 cm in size occur in its upper part, most commonly in the eastern part of the area.

Sedimentary structures consist of trough crossbeds, generally not thicker than 60 cm and indicating southward paleotransport (Fig. 13), planar crossbeds, wave ripples and planar bedding. Except for two occurrences of possible mud chip moulds, careful search revealed no evidence of mud chips, mudstone drapes or desiccation cracks in the member.

Ripple mark orientations were collected over a stratigraphic thickness of about 10 m from site C487, a continuous exposure of red sandstone about 800 m long and 300 m wide at the boundary with the Agu Bay Formation. The crests of 96 linear and sinuous symmetrical wave ripples (Fig. 14) show a major mode oriented at about azimuth 30°, suggesting a similarly oriented shoreline. A strong subsidiary east-west mode is also present.

Inspection of seventeen thin sections indicates that the Whyte Inlet Formation is a quartz arenite of generally high sphericity and rounding, and varied to good sorting. Some thin sections possessed bimodal texture and detrital mica is absent in all sections but one. Heavy minerals consist of zircon and tourmaline, of high sphericity and rounding (Fig. 15a, b). Some samples are red due to fine grained hematite coating the detrital outlines of quartz grains.

Autridge Formation

This formation was named by Blackadar (1970), the type area being west of the head of Autridge Bay.

Mikkelsen Member

A facies of interbedded sandstone, siltstone and shale, about 1500 m thick, intervenes between the Whyte Inlet Formation and the black shale of the Autridge Formation.

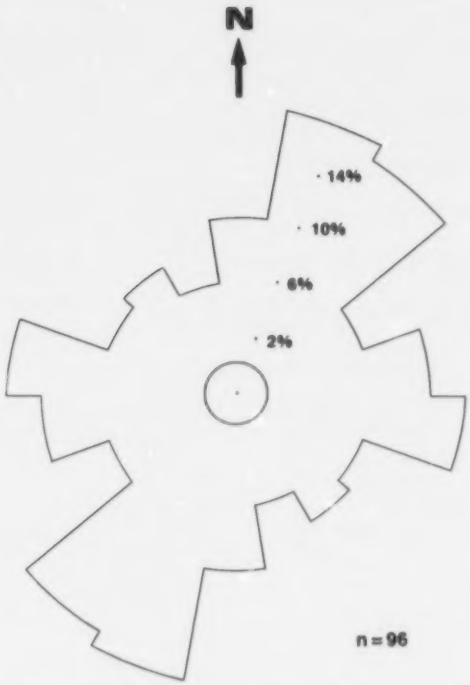


Figure 14. Orientation of crests of wave ripples, red sandstone at boundary between Agu Bay Formation and Whyte Inlet Formation.

It strikes eastward from Cape Einar Mikkelsen, after which it is named, to the longitude of the mouth of Autridge Bay. The cape lies on the coast of Baffin Island at longitude 86°35', latitude 70°15'. Because of the thickness and mappability this lithologically intermediate facies, Chandler et al. (1980) recognized it as a separate unit, the "transition formation", within Blackadar's (1970) Fury and Hecla Formation. In this report the unit is given member status. Because of the black shale and syneresis cracks that separate it from the Whyte Inlet Formation and give it affinity with the Autridge Formation, the member is included in the latter.

Traverses across weathered outcrop of the poorly exposed member and its overlying felsenmeer give a picture of drab and red sandstone of a range of grain size, light coloured quartzite and red, dark green and black shale. Cliff sections exposing the fresh rock (site C517), however, show a dominance of grey quartzite and black shale. The unit changes upward by increasing amounts of syneresis-cracked black shale in units up to 2.5 m thick interbedded with flaser and lenticularly bedded rippled and crossbedded quartz arenite.

From 15 thin sections, sandstone of the Mikkelsen Member appears to be well rounded, generally well sorted quartz arenite cemented by quartz and containing minor matrix muscovite. Diagenetic hematite flakes are present in red examples and chlorite in drab specimens. In fine grained sandstone and siltstones, detrital muscovite and biotite flakes are present as well as traces of feldspar. But only one example contains enough feldspar to warrant the name subarkose. In many samples tourmaline and zircon heavy mineral grains are of high sphericity and roundness.

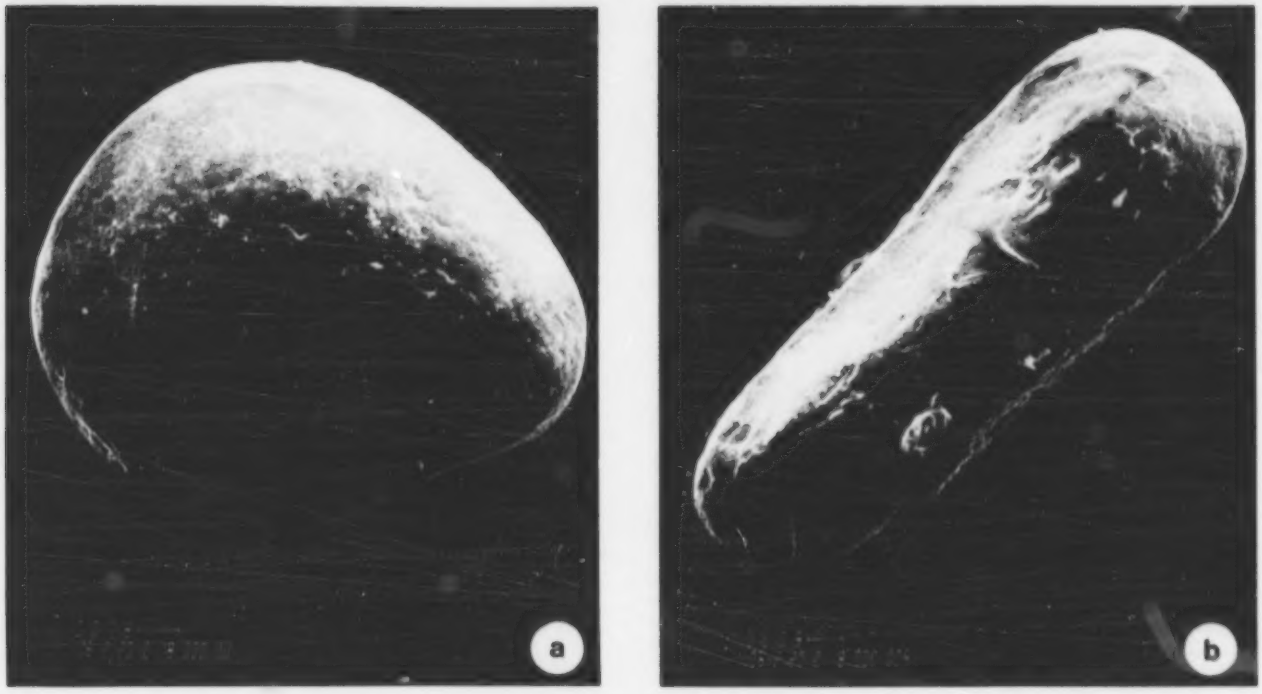


Figure 15. Shape of zircon heavy mineral grains, Whyte Inlet Formation. Scanning electron microscope photographs of representative grains of high (a) and low (b) sphericity. Bar scale is 100 microns long.

Cape Appel Member

The member is named after Cape Appel at 86°15'N. About 500 m of black shale of the Autridge Formation is well exposed in stream banks up to 12 m high that run almost continuously for about 4 km along the strike of the formation about 3 km north of Cape Appel. About 5 % of the section is composed of separate beds of well sorted quartz arenite ranging from trains of isolated ripples to beds 10 cm thick (Fig. 16a). The arenite beds include massive grit layers, sand units that are planar-crossbedded, wave-rippled and flat-bedded, and rippled units that are fine grained and wavy to lenticular bedded (Fig. 16b). Other sand beds consist of laminated fine grained sand with a basal grit layer.

Syneresis cracks (Fig. 16c) are abundant, some of which might have been mistaken for mudcracks (Blackadar, 1970, p. 43). Most are connected with the base of quartz arenite beds, taper downward and are filled with quartz grains like those of the overlying beds. Some taper upward from the upper surfaces of sandstone beds, a feature of substratal syneresis cracks as opposed to subaerial desiccation cracks (Plummer and Gostin, 1981, p. 1152). Others are isolated in the shale and are spindle-shaped in vertical cross-section. The cracks may be vertical or inclined and unlike mudcracks are not concentrated in certain layers. Nor are any mud chips or upward-curled mud layers present that might have been formed by subaerial desiccation. In plan view the syneresis cracks are lenticular and in many cases isolated (Fig. 16d).

Four samples of fine grained sandstone and siltstone were rich enough in quartz to be classed as quartz arenite, but contained either enough feldspar or carbonate, possibly after feldspar, to be close to subarkose. The quartz grains are well rounded and sorted, are quartz cemented and contain varied amounts of detrital muscovite and biotite flakes. Heavy minerals can be well rounded or angular. One sample consisted of silt-sized carbonate with a trace of quartz silt, sparse patches of diagenetic pyrite and irregular, black, possibly organic?, laminae.

Sedimentological interpretation

Even though this paper embodies the results of a brief reconnaissance survey of an area heavily blanketed with felsenmeer, some significant observations were made that provide the basis for the following tentative synthesis of the sedimentology of the Fury and Hecla Group.

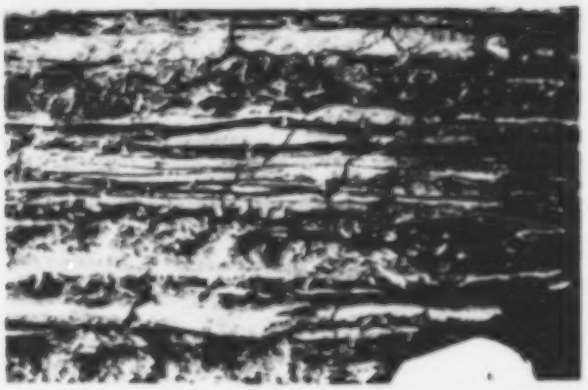
Within the Nyeboe Formation mudcracks in the shaly units (members 2, 4, 6) and the fluvial fabric of the quartz-rich conglomerate (member 3) point to several subaerial phases during the deposition of the member. The dolomitic member 5 contains stromatolites and oolites and therefore could be marine or lacustrine, but some observations of herringbone crossbeds, likely evidence of tidal activity, favour the marine interpretation. Well rounded quartz grains set in oolitic carbonate are reminiscent of "miliolite", that forms on coastal regions of the hot arid Persian Gulf where eolian quartz sand dunes march onto oolitic shallow marine environments (Evans et al., 1973, p. 235). Westward thinning of the quartz-rich conglomerate, member 3, and eastward pinchout of the dolomitic member 5 and the paleocurrent pattern of member 3 point to a broadly westward change from alluvial to marine environments.

Petrographic observation of high textural maturity of both framework quartz grains and of rare zircon heavy mineral grains in the Sikosak Bay Formation indicate a rigorous abrasion history common in the shallow marine environment, an inference supported by presence of

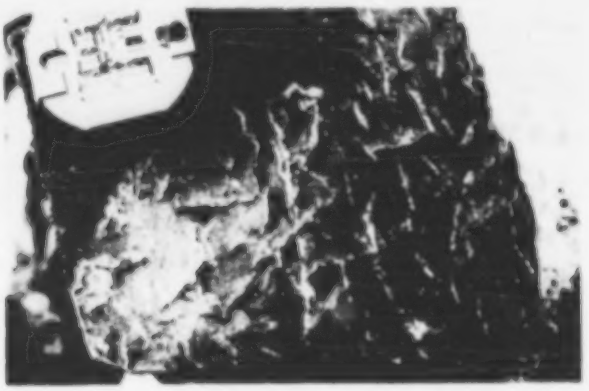
Figure 16. Cape Appel Member, Autridge Formation, site C520

(a) Seven metre high cliff of black shale, typical of the member; strata dip gently away from the observer. White layers on the cliff face are thin quartz arenite beds shown in detail in Figures 16b and c. (GSC 203989-D)

(b) Rippled quartz arenite bed, "A", underlain by black siltstone and shale and overlain by lenticularly bedded grey siltstone. (GSC 203989-G)



(c) Vertical view of quartz sand-filled syneresis cracks, extending downward from quartz arenite sand ripples and laminae. These cracks are ptygmatic probably because of compaction of enclosing shale. (GSC 203989-E)



(d) Plan view of syneresis cracks in base of sandstone bed. Note typical isolated, lanceolate form of quartz arenite crack fillings. (GSC 203989-F)

herringbone crossbeds in the member. North-south orientation of most crests of the abundant linear wave-ripples of the member points to a north-south shoreline and rare trough crossbed measurements (Fig. 8) suggest southward shore-parallel migration of sand. Accepting the Hansen Formation to be a time marker, occurrence of the basalt successively lower in the quartzite westward would indicate deposition of the Sikosak Bay Formation as a west-migrating facies.

Mudcracks indicate periodic exposure during the deposition of the Dolomite Member of the Agu Bay Formation. Sand waves, wave ripples, oolites and abraded fragments of stromatolite laminae that form nuclei for oncolite formation show vigorous current action and wave activity in water at most several metres deep. Upward branching filament moulds, seen in thin section, lie at right angles to the surface of the lamination of the stromatolites. They indicate an organic, possibly algal, contribution to the formation of the stromatolite domes. Raised walls rimming truncated stromatolite domes (atoll structure) contain laminae that are draped over truncated remnants of an earlier dome. This structure documents the attempts of the dome-forming organisms to re-establish themselves in an energetic shoal environment before being finally overwhelmed by the mud of the overlying Black Shale Member. Deposition of the Dolomite Member directly upon the probably tidal marine Sikosak Bay Formation suggests that the dolomite was probably deposited on tidal flats. Elongation of some stromatolite domes at azimuth 060°, a feature that could have been caused by shore-normal tidal or wave action, is consistent with evidence from other units that the sea may have lain to the west rather than to the north or south.

The colour of the Black Shale Member and the absence of desiccation features indicate subaqueous deposition. Interbedded grey sandstones with crossbeds and ripples point to periodic generation of traction currents capable of transporting sand. Association of abundant syneresis cracks with these quartz arenite and oolite sandstones and occurrence of multidirectional small-scale crossbeds argue for a tidal marine environment. Presence of fragments of filament mould-bearing algal? mat similar to that comprising the stromatolite domes of the Dolomite Member suggests that some of the sand was swept into deeper water from the intertidal zone, and that the Black Shale Member may have been a deeper water, i.e. subtidal facies equivalent lying to the west of the Dolomite Member.

From their common sedimentary structure sequence and their even thickness over hundreds of metres, the upward coarsening sandstones within the Black Shale Member appear to be a distinct facies. Five similar sandstones, of

Mesozoic age, lying within shale were interpreted by Brenner (1980) to have been deposited in an epicontinental seaway of the western interior of the U.S.A. mainly under the influence of currents of storm and tidal origin. They lack evidence of exposure and some may have been deposited many kilometres from coeval shorelines. Four of the Mesozoic examples are 10-15 m thick, somewhat thicker that the sandstone in the Black Shale Member of the Agu Bay Formation, but one late Cretaceous example, the Woodside unit (Cotter, 1975), consists of 3 beds of moderately mature quartz arenite 0.6-1.5 m thick separated by 2-3 m of bioturbated silty shale, and therefore have a scale and setting in shale comparable to the sandstones in the Black Shale Member of the Fury and Hecla Group. The sandstones of the Woodside unit consists of bioturbated sandstone interlayered with or overlain by planar or trough crossbedded, rarely laminated coarser sand. Some crossbeds opposed at nearly 180° indicate tidal activity. The Woodside unit was interpreted (Cotter, 1975) as a complex of non-emergent, offshore, shallow marine, shelf sand bars.

Reading (1978) also reviewed shallow marine sand bar deposits and concluded that both tidally and storm generated currents form coarsening-upward sequences due to migration of linear sand bars over finer grained interbar trough deposits within a muddy low energy marine shelf environment. Opposed crossbeds, evidence of tidal activity, may be used to separate the tidal from the storm generated beds.

The quartz arenite and carbonate granule (oolite?) beds within the Black Shale Member coarsen and thicken upward. They lack evidence of exposure and contain syneresis cracks. These features and other sedimentary structures already listed fit with deposition by traction currents in a subaqueous muddy environment. Multidirectional crossbeds suggest that tidal currents were involved. A pebble lag at the top of one of the units may be the result of wave-reworking of bar crests (Berg, 1975). The above features suggest a similarity with the Mesozoic shallow marine sandstones.

The Redbed Member of the Agu Bay Formation coarsens up from a red siltstone-dominated lower part to a red sandstone-dominated upper part that bears abundant evidence of emergence and terminates in a widespread red mudcracked shale. Coupled with the underlying subaqueous shallow marine Black Shale Member it represents a regressive upward-coarsening megacycle.

Superimposed on the megacycle are second order upward-coarsening (meso)cycles 10-20 m thick and within the upper part of each second order cycle lie a number of third order upward-fining (mini)cycles. Thus the Redbed Member is a sequence of cycles nested at three levels.

The second order cycles commence with basal laminated red or black shale lacking evidence of emergence, coarsen up through silt with increasingly larger sand ripples and an increasing abundance of mudcracks to terminate in sandstone composed of upward-fining cycles up to 30 cm thick. These upward-fining third order cycles commence with a basal mud chip lag that is overlain in succession by crossbedded sandstone, rippled fine grained sandstone and siltstone and terminate in a desiccation-cracked mudstone layer.

The second order cycles, especially where the basal mudstone is black, seem to represent smaller scale versions of the larger scale regressive cycle formed by the Black Shale and Redbed members. The third order cycles, present in the upper sandy part of the second order cycles, probably are the record of subaerial floods. Multidirectional and opposed crossbeds in these third-order upward-fining cycles suggest that they are in part at least the result of tidal activity in a coastal region. The widespread hard, shiny mudcracked shale present at the top of the upper Redbed Member may have been deposited on a coastal mudflat.

A large thickness of large scale crossbeds, a good criterion for an eolian mode of deposition (Walker and Middleton, 1977), is absent from the Whyte Inlet Formation, as are indicators of exposure such as mudcracks and mud chips and upward-fining flood cycles characteristic of alluvial successions. The above constraints as well as the dominance of crossbeds and wave ripples as almost the sole sedimentary structures fit with deposition of the member in a body of standing water.

Petrographic criteria, i.e. textural and mineralogical maturity of both the heavy (Pettijohn, 1975, Fig. 7-3, 7-4) and light (Klein, 1977, p. 72 et seq.) mineral fractions as well as the virtual absence of detrital mica flakes are all consistent with a shallow marine mode of deposition.

A current rose for wave ripples (Fig. 14) from the base of the formation fits with a local NNE-trending shoreline and a major secondary mode may suggest a tidal marine current pattern (Klein, 1977, p. 71).

Other data from the Fury and Hecla Group, e.g. western increase in importance of shaly facies versus arenaceous and conglomerate (fluvial) facies and the eastward pinch out of carbonates, suggest that the sea lay to the west. This inference is supported by Jackson and Ianelli's (1981, Fig. 16, 27) conclusion, from probably equivalent rocks 250 km north of the Fury and Hecla Strait area, that the sea lay to the northwest.

Accepting the above shoreline trend, the few trough crossbeds measured from the Whyte Inlet Formation may be the result of longshore currents, and interestingly parallel those recorded from the Sikosak Bay Formation.

Among shallow water-to-emergent settings that quartz arenites commonly occupy are the eolian, fluvial and shallow marine depositional environments. Field sedimentological data from the Whyte Inlet Formation and enclosing units suggest that the eolian setting is the least likely and the shallow marine setting is most likely.

Zircons newly derived by weathering from granites are generally euhedral-prismatic with pyramidal terminations (Poldervaart, 1956, p. 352; Pettijohn, 1975, p. 206). Zircon heavy mineral grains from a first-cycle sandstone derived from a granitic shield terrane, e.g. quartz arenite formed by weathering, would be expected to contain a recognizable amount of unabraded zircons, a possible example being the upper member of the Aphebian Lorrain Formation of Ontario (Chandler, 1984), as well having poorly sorted and rounded framework quartz grains. In contrast shallow marine quartz arenites seem to have a high textural maturity both in the framework quartz grains (Klein, 1977, p. 119) and in zircon heavy mineral grains (Pettijohn, 1975, p. 207), an example being the Ordovician St. Peter sandstone of Minnesota, interpreted as shallow marine (Fraser, 1976; Galloway and Hobday, 1983, p. 159).

In order to test further the inference that the Whyte Inlet Formation might have been deposited in a shallow marine setting, zircons were concentrated by Jennifer Graves from three samples, L393 from near the base and samples L36 and C132 from the middle of the formation. Typical representatives of the largest grains from the concentrates were picked using a 40x binocular microscope and mounted for examination with the scanning electron microscope. Secondary electrons were used to produce photographs with a good depth of field. The larger grains, being more sensitive to abrasion, were chosen because any euhedral examples would have a higher significance.

Typical grains from the three samples e.g. Figure 15a, a high sphericity grain and Figure 15b, a low sphericity grain, show that the samples were very well rounded, thus supporting the contention that the thick quartzite member might have a shallow marine origin.

The black colour of the Autridge Formation shale, absence of evidence of emergence, and presence of syneresis cracks point to a subaqueous, possibly marine, environment of deposition.

Presence of a small amount of well sorted rippled quartz arenite beds in the Cape Appel Member points to periodic disturbance of the environment by storms or traction currents of moderate velocity. Similar beds have been described from the muddy marine shelf environment by Allen (1982, p. 487 et. seq.), and Reading (1978, Fig. 9.50) and have been interpreted as of storm origin. Absence of beds resembling Bouma sequences among the sand beds in the Autridge Formation indicates that the slope of the depositional environment was low (Allen, 1982, p. 505).

The sedimentology of the Whyte Inlet and Autridge formations is consistent with interpretation of both as a seaward-fining facies assemblage of marine-shelf deposits. The west-thinning thick quartzite of the Whyte Inlet Formation might represent a shallow inner shelf facies from which mud was removed offshore to the quieter depositional environment of the deeper outer shelf in the west to be deposited as the Autridge Formation. Periodic storms could have generated traction currents and lowered wave base in the offshore muddy shelf environment (Cape Appel Member) carrying to it quartz sand from the sandy inner shelf (Allen, 1982), most of which was deposited in the intervening, relatively sandy Mikkelsen Member facies belt.

Dybbol Sill and mafic dykes

A well exposed gently south-dipping, columnar-jointed mafic sill forms a 57 km long east trending peninsula that encloses Autridge Bay. It is named after Dybbol Harbour on the peninsula. The sill is the stratigraphically highest unit in the late Proterozoic sequence on the north Shore of Fury and Hecla Strait. Presence of black shale of the Autridge Formation beneath the sill on the south shore of Autridge Bay (see frontispiece of Blackadar, 1970) and of the Autridge Formation in islands up-section to the south indicate that the intrusive lies within the Autridge Formation. In the bank of a stream 5 km northwest of Cape Appel a contact alteration zone at least 12 m thick has been formed in the black shale of the Autridge Formation at the base of the sill.

Several sills shown by Blackadar (1970, map and p. 74) to lie within the Fury and Hecla Formation east of Agu Bay are probably exposures of the volcanic Hansen Formation, that was previously identified by the writer as a sill (Chandler et al., 1980).

K-Ar whole-rock ages of 716 ± 166 and 746 ± 87 Ma from two samples from the Dybbol Sill (Chandler and Stevens, 1981) are regarded as Franklin ages.

The sill is chemically fresher than the other igneous units chemically analyzed (Table 1). Like member 6 of the Nyeboe Formation and the Hansen Formation it has low values for most of the incompatible elements such as TiO_2, K_2O and Zr and high MgO and Cr, in comparison with other continental basalts. These data suggest (W.R.A. Baragar, personal communication, 1985) a close connection with ocean opening.

West-northwest-striking mafic dykes cut the Fury and Hecla Group. Thicknesses of the dykes are 3, >15, 18, 18, 21, 31, 34, 38, 100 and 107 m. The dykes stand out as ridges and because it was not possible to trace them across many of the east-west faults transecting the area they probably predate the faults. Four chemical analyses are given on (Table 1). Four thin sections show variably altered clinopyroxene and plagioclase and replacement of olivine by iddingsite. Quartz, biotite, chlorite and opaque grains are plentiful. Two dykes, sample sites[1] shown on the map (Fig. 2), yielded K-Ar whole-rock ages of 631 ± 43 and 643 ± 47 Ma. Also it is quite likely that the dykes are slightly younger than the sill because one dyke probably (based on air photo interpretation) cuts the sill. Being slightly younger than the dates of the Dybbol Sill, these dates are regarded as reset Franklin ages (Chandler and Stevens, 1981).

The dyke chemistry is variable and two analyses (Table 1, columns 13 and 14) could be related in tectonic setting to the other units of Table 1. The high K_2O and Zr and low MgO and Cr argue against such a relation for column 11.

Metamorphism and structure

Prehnite and pumpellyite (visual identification by R.K. Herd) in amygdules in basalt flows in the Fury and Hecla Group indicate low grade, subgreenschist conditions (Turner, 1980). No other metamorphic minerals were recognized in the supracrustal rocks of the area.

Earlier mapping, (Blackadar, 1958) indicated that on the north shore of the Fury and Hecla Strait the group dips gently and homoclinally to the south and southeast. Work in 1979 (Fig. 2, in pocket) confirms this observation with the additional recognition of a gently east-plunging anticline affecting the Mikkelsen Member of the Autridge Formation about 5 km northwest of the head of Autridge Bay. Faults striking both northwest, a trend assumed by later dykes, and east predominate in the supracrustal rocks. A small number of north-striking faults are present. As is clearly demonstrated in the reasonably well exposed lower formations of the Fury and Hecla Group, north of Whyte Inlet upthrow is mainly to the south. That this sense of movement and style of faulting continues on the southern shore of Fury and Hecla Strait is suggested by the following; on the northern shore of Melville Peninsula (Blackadar, 1958), strata interpreted from air photographs by the writer to be equivalent to the basal part of the Fury and Hecla Group, south of East Cape, dip gently southwest toward a fault contact with the basement; on Amherst Island (Fig. 1b) carbonates presumably higher in the Autridge Formation than strata exposed on the northern shore of Fury and Hecla Strait are exposed, gently dipping, only 5 km north of the basement, therefore much of the group is presumably downfaulted. Farther east, at Northeast Cape, (Blackadar, 1958) the writer found that strata of the Fury and Hecla Group are vertical where they are faulted against the basement that lies on the south side of an east-west fault.

Consequently the limited data available for the region, including absence and fault-related facies to be expected in grabens, and probable post-Franklin age of some east-striking faults, suggest that rather than being preserved in an aulacogen as suggested by Jackson and Ianelli (1981, p. 296 et seq.) the Fury and Hecla Group is preserved by being downthrown on the northern sides of a series of east and northwest-striking faults.

Age, correlation and tectonics

Ciesielski (1983) described the granites of the basement as late tectonic and presumably Archean because of some similarity with some Archean granites of the Superior Province. A good seven-point Rb-Sr isochron, in preparation at the Geological Survey of Canada in Ottawa, indicates the age of the eastern radioactive pluton adjacent to the unconformity beneath the Fury and Hecla Group to be 1817 ± 14 Ma. U-Pb measurements on zircons show incorporation of Archean material (Y.T. Maurice and R.W. Sullivan, personal communication, 1983) and A. Ciesielski (personal communication, 1984). Thus Hudsonan reactivation may have affected an Archean basement beneath the Fury and Hecla Group.

[1] Site numbers of dated igneous rocks correspond to those of Chandler and Stevens (1981).

Two thick, probably late Precambrian supracrustal sequences occur in north-western Baffin Island (Fig. 1a) one, the Fury and Hecla Group (Blackadar, 1970; Chandler et al., 1980) and the other, the Eqalulik and Uluksan groups (Blackadar, 1970; Jackson and Davidson, 1974; Jackson et al., 1975, 1978). Jackson and Ianelli (1981) recently separated the upper part of the Uluksan Group as the newly created Nunutsiaq Group, arranging the three groups into the new Bylot Supergroup. The Bylot Supergroup is overlain by Early Paleozoic strata, (Trettin, 1969).

Lithological similarities between the two late Precambrian sequences have prompted their correlation. Early K-Ar dates from mafic volcanic rocks near the base of the sequences and from sills and dykes cutting the sequences (Blackadar, 1970) were confusing because they did not agree with field relations and in some cases a wide range of ages was derived from the same unit (Blackadar, 1970; Jackson and Ianelli, 1981). But Chandler and Stevens (1981) reported three well-grouped K-Ar whole-rock ages from the volcanic rocks at the base of the Fury and Hecla Group (member 6, Nyeboe Formation) at about 1100 Ma and two ages from a mafic sill (Dybbol Sill) within the Autridge Formation of 716 and 746 Ma. Two dykes, one of which on the basis of air photograph interpretation appears to cut the sill, have K-Ar ages of 631 and 643 Ma.

These most recent ages, which also fit with geological field relations and are not dissimilar to the ages of the great periods of dyke formation at 1200 Ma (Mackenzie) and 700 Ma (Franklin), bracket the sedimentation of the Fury and Hecla Group, suggesting that sedimentation started during the Neohelikian subera and ceased before the middle of the Hadrynian Era (Chandler and Stevens, 1981).

The Fury and Hecla Group is therefore linked by dating of the Nyeboe Formation basalt and the Dybbol Sill to several broadly similar sedimentary sequences of the Canadian Arctic region and Greenland. The sequences themselves are linked in age by included mafic igneous rocks of Mackenzie (1200 Ma) age and by carrying a Mackenzie-type of paleomagnetic signature (Jackson and Ianelli, 1981, p. 295).

The Bylot Supergroup, a sequence of strata probably correlative in part with the Fury and Hecla Group, lies 200 km to the north (Fig. 1a) and is divided into three groups, the mainly clastic Eqalulik Group, the overlying carbonate Uluksan Group and the topmost Nunatsiaq Group. Both the Bylot Supergroup and the Fury and Hecla Group were interpreted by Jackson and Ianelli (1981) to have been deposited in failed arms opening northwest into a Neohelikian ocean. Jackson and Ianelli (1981) interpreted the Fury and Hecla Group to be stratigraphically equivalent to the Eqalulik Group, that comprises 40% of their succession.

Inititial sediments of the Bylot Supergroup include the Nauyat and Adams Sound formations, about 1000 m of fluvial and marginal marine quartz arenite with subaerial continental basalts deposited on a peneplaned gneiss complex. According to Galley (1978) the basalts thin southeastward, are associated with northwest-striking faults active during deposition of the sediments, and may represent the initial stage of opening of a Helikian ocean to the northwest. Jackson and Ianelli's (1981) illustration (Fig. 16.27) showing distribution of these two formations implies development of a trough on the site of the future failed arm.

The Nauyat and Adams Sound formations are overlain by the laterally equivalent Arctic Bay and Fabricius Fjord formations, the latter a coarse grained facies related to syn-sedimentary faulting. The first of two phases of a major intrabasinal faulting was believed to have commenced during deposition of these overlying formations.

The lower part of the 180-770 m thick Arctic Bay Formation consists of up to 50 m of drab herringbone-crossbedded quartz arenite overlain by about 800 m of upward-coarsening cycles of black shale, grey shale-siltstone-quartz arenite and drab quartz arenite with herringbone crossbeds. Other features of the formation include a shale-dominated middle part, dolostone-terminated cycles and syneresis cracks. The formation was interpreted (Jackson and Ianelli, 1981) to have been deposited in intertidal and subtidal environments with the cycles formed in marine-influenced clastic shoreline and deltaic regimes.

The laterally equivalent Fabricius Fjord Formation commences with black shale containing upward-coarsening black shale to quartz arenite cycles similar to those of the Arctic Bay Formation. A point of interest is that Jackson and Ianelli (1981) observed that the cyclic nature of the unit gave exposures a characteristic ribbed appearance, a point made for the Redbed Member of the Agu Bay Formation in this report. The upper part of the Fabricius Fjord Formation

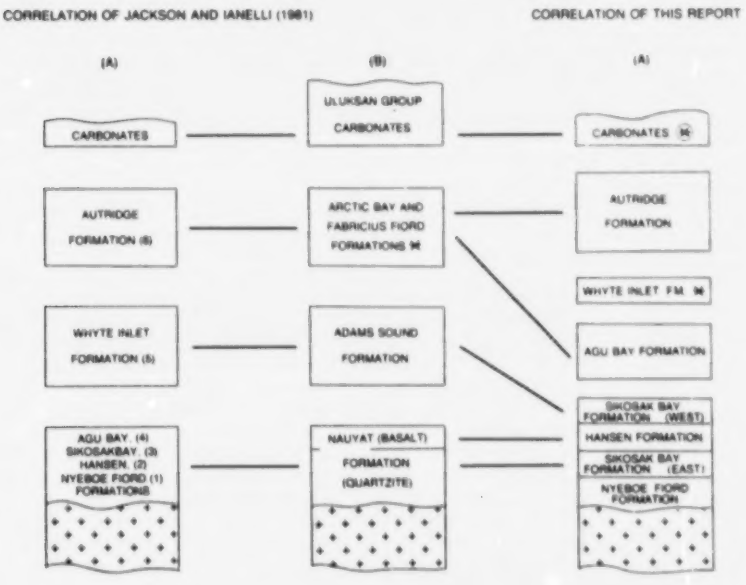


Figure 17

Stratigraphic correlation of the Fury and Hecla Group (A) with the Bylot Supergroup (B). In Jackson and Ianelli's (1981) correlation earlier nomenclature (Chandler et al., 1980) of the Fury and Hecla Group is given as follows: 1 and 3, lower redbed formation; 2, mafic sill; 4, upper redbed formation; 5, pink quartzite formation; 6, transition formation and Autridge Formation.

⊙ Carbonates presumably overlying the Autridge Formation, as mapped by the writer were shown by Blackadar (1958) to occur to the southeast on an island in Fury and Hecla Strait.

* Whyte Inlet and Fabricius Fjord formations regarded as local facies (see text for description).

consists of subarkose, in some places pebbly, and quartz arenite overlain by a heterogeneous unit containing wedges, adjacent to faults, of massive breccia conglomerate.

The Fabricius Fjord Formation, comprising an upward coarsening megacycle, was interpreted by Jackson and Ianelli (1981) as deposited in marine-influenced delta-fan complexes adjacent to the Central Borden Fault Zone.

The overlying Uluksan Group consists of two stromatolitic carbonate formations deposited in shallow subtidal to supratidal environments. Apart from its basal formation, the succeeding Nunatsiaq Group is dominated by terrestrial clastics included alluvial fan complexes formed during the second major phase of faulting in the basin. This phase also resulted in the karsting of the carbonates of the underlying Uluksan Group that is related to the lead-zinc mineralization at Arctic Bay (see Economic geology). The upper part of the Nunatsiaq Group is composed of alluvial to marine sandstone and peritidal carbonate formed during decay of the tectonic activity. Jackson and Ianelli (1981, p. 295) correlated the Redbed Member of the Agu Bay Formation (upper redbed formation, Chandler et al., 1980) and underlying units of the Fury and Hecla Group with their Nauyat Formation (Fig. 17). They correlated the Whyte Inlet Formation (pink quartzite formation, Chandler et al., 1980) and the Autridge Formation (transition and Autridge formations, Chandler et al., 1980) with their Adams Sound and Arctic Bay-Fabricius Fjord formations respectively.

Work on the Fury and Hecla Group, however, shows a marked similarity in facies and facies sequence between the Nauyat Formation – Adams Sound formations and the Nyeboe – Hansen – Sikosak Bay formations. Like the lower units of the Fury and Hecla Group, the Nauyat Formation consists of a quartz arenite-dominated lower part containing one or two basalt flows overlain by a basalt member, with southeastward thinning and pinchout of the volcanic units (Fig. 3). Position of parts of the Sikosak Bay Formation above and beneath the Hansen Formation (Fig. 3) allows correlation of parts of this quartzite with either Nauyat Formation or Adams Sound Formation quartzite.

Correlation of the Agu Bay – Autridge formations with the Arctic Bay – Fabricius Fjord formations is not stratightforward. First, Jackson and Ianelli (1981) correlated the Whyte Inlet Formation with their Adams Sound Formation. This correlation is suspect because of the drastic westward thinning and almost complete pinch out of the former. There appear to be other major facies differences between and within the two sequences. As sketched above, the Fabricius Fjord Formation is an upward-corsening sequence, terminating in immature faulting-related conglomerate, whereas the equivalent Arctic Bay Formation is a fining- then coarsening-upward sequence of black shale containing mainly shale-quartzite upward-coarsening cycles.

As described in this report the Agu Bay – Autridge Formation sequence of the Fury and Hecla Strait area differs from those of the Bylot Supergroup by coarsening, then fining upward. If, however, the conglomerate in the Fabricius Fjord Formation and sandstone in the Whyte Inlet Formation are regarded as local facies, there is significant similarity between the Arctic Bay Formation and the Agu Bay and Autridge formations. Both are essentially shallow marine shale sequences containing smaller scale upward- coarsening shale-sandstone cycles. Correlation of the Arctic Bay Formation with the Agu Bay and Autridge formations is enhanced by their position beneath carbonate sequences, correlated by Jackson and Ianelli (1981).

Immature breccia-conglomerates associated with red sandstones were used by Jackson and Ianelli (1981) as evidence of graben formation during deposition of the Fabricius Fjord Formation. There is no evidence of such conglomerates anywhere in the Fury and Hecla Group. However, at probably the same stratigraphic position in the upper Redbed Member of the Agu Bay Formation, upward-coarsening sandstone cycles, with associated mudcracks (megacycle and mesocycles) may be pulses of how clastic debris related to the faulting 150 km to the north.

In conclusion, correlation of the Fury and Hecla Group with the Bylot Supergroup is supported, but the writer is not convinced at present of some of the details of Jackson and Ianelli's (1981) correlations. The presence of eastward-thinning basalts in the lower part of the succession, the chemistry of mafic igneous units in the succession (Table 1, and text) and the increasingly "marine aspect" of sedimentary units toward the west support their suggestion that a newly opening ocean lay to the west or northwest. There is, however, no evidence of failed arm formation in the Fury and Hecla Strait area itself, although some aspects of sedimentation in that area may reflect graben formation in the site of deposition of the Bylot Supergroup.

ECONOMIC GEOLOGY

Three types of mineralization are discussed for the following reasons. Follow-up work on geophysically discovered radioactive anomalies over the granite basement and the supracrustal sequence showed uranium occurrences in a geological environment with similarities to that of the unconformity-related mineralization of Saskatchewan and Australia. Lead and zinc are mined from rocks of the Bylot Supergroup at Nanisivik (Olson, 1977), probably equivalent to Autridge Formation carbonates. Brief reference is made to gold because of the presence of quartz-rich conglomerate in the Fury and Hecla Group.

Uranium

During the last decade large reserves of uranium have been discovered in Saskatchewan, and in the Northern Territory of Australia, that belong to the unconformity-related type of uranium deposit. In these deposits the uranium occurs at or near the unconformity between an Aphebian metasedimentary basement and overlying late Proterozoic sandstone. In the basement rocks it is found in calc-silicates, graphitic pelite or mobilizate bodies, and can be accompanied by chloritic or hematitic alteration. Many examples of the mineralization occur in or near faults cutting both basement and overlying sandstone. Various theories, from hydrothermal to surficial, have been proposed for the formation of some of these deposits, (Dahlkamp, 1978; Eupene, 1980; Hoeve and Sibbald, 1978; Langford, 1977; Munday, 1979).

The age, structural relations and composition of the rocks of the Fury and Hecla Strait area bear resemblances to those in western Canada and Australia that carry large amounts of uranium. Differences include the advanced granitization of the basement of Baffin Island and apparent absence of graphitic pelites within it, also absence of a thick Helikian paleosol beneath the Fury and Hecla Group. Added interest in the Fury and Hecla Strait region comes from the discovery of the radioactive granitic rocks in the basement adjacent to the unconformity beneath the Fury and Hecla Group. The radioactivity is concentrated in two distinct anomalies (Fig. 18; see Chandler et al., 1980, p. 27). The rocks underlying the eastern anomaly north of Whyte Inlet (Ciesielski and Maley, 1980), mapped largely by Ciesielski, consist of a "late" granite pluton with pegmatites, largely surrounded by mesocratic to leucocratic orthogneiss with inclusions of ultramafic material, amphibolite and iron-formation. The five occurrences of uranium mineralization shown by Ciesielski and Maley (1980) are adjacent to faults separating the late granite from the redbeds of the basal part

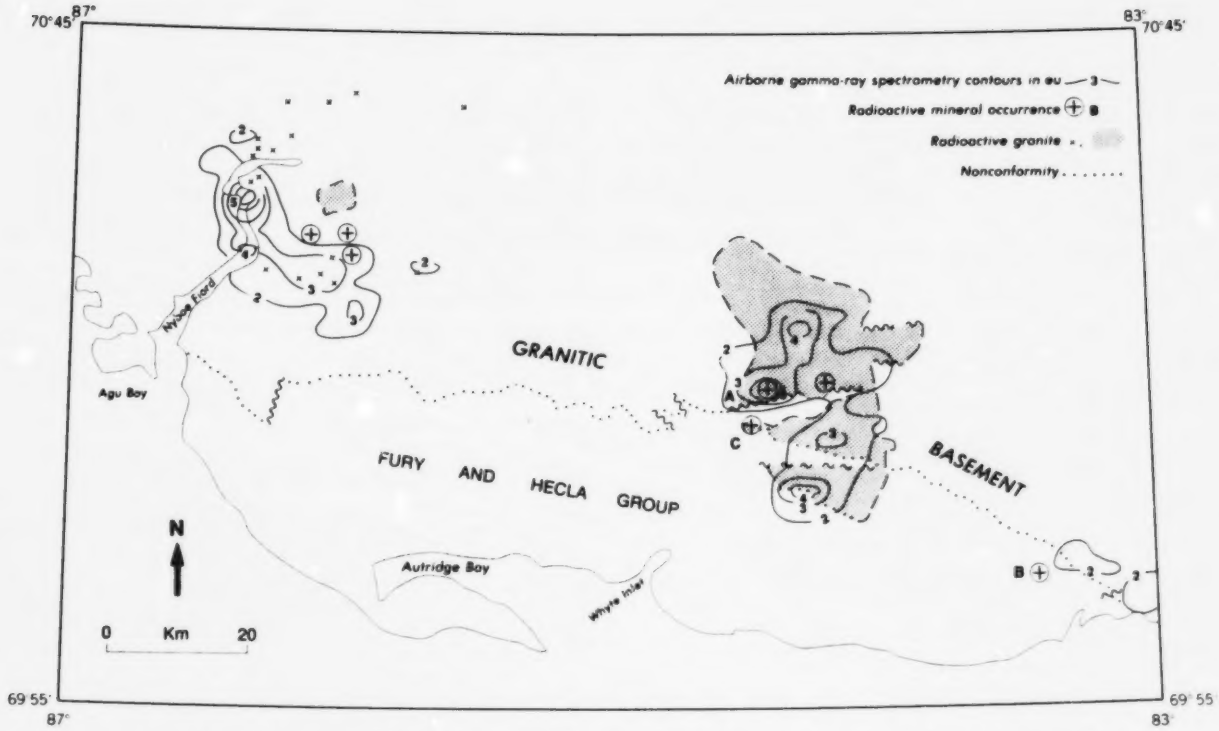


Figure 18. Radioactive mineral occurrences, basement granites and airborne radiometric anomalies associated with the nonconformity beneath the Fury and Hecla Group, modified from Chandler et al. (1980, Fig. 20.2). Lettered occurrences are discussed in text.

Figure 19. Aerial view of resistant radioactive quartz stockwork in fault between felsenmeer-covered redbeds of the Nyeboe, Formation (A) and granitic basement (B). GSC 203901-V, occurrence C, Fig. 18.

of the Nyeboe Formation. The area underlying the western anomaly, on Nyeboe Fjord, largely mapped by Maley, consists of areas of granite orthogneiss and a range of paragneisses including a strongly banded variety with minor amounts of ultramafic and amphibolitic material and iron-formation. Of twelve uranium showings depicted by Ciesielski and Maley (1980) eight lie within or adjacent to strongly banded paragneiss.

Ciesielski (1983) described the granites underlying the anomalies as anatectic and developed from hybrid orthogneiss and paragneiss but without an evident sedimentary source. Although he felt that the granites could not be fitted into the I and S type classification of Chappell and White (1974), the opaque mineral assemblage suggested (K. Currie, personal communication, 1983) affinity with the I type.

Maurice (1982) found the main radioactive unit beneath the large eastern and western anomalies to be uranium-rich, massive, homogeneous, alkaline biotite granite (Fig. 18). In the east a 500 km^2 pluton is well defined and exposed and cuts mesocratic, nonradioactive gneisses. Under the western anomaly erosion is less deep and smaller separate bodies of granite lie within gneisses of a range of compositions. The economically most interesting uranium mineralization occurs in veins in the granite. In the west, pegmatites, marginal to a presumably subjacent pluton, carry the uranium. The pegmatites are assumed to have been stripped by the greater erosion in the east. In the Nyeboe Formation and at faults separating it from the basement (Fig. 19) the veins are limonitized and carry oxidized uranium minerals at the surface. At depth (D. Fisher in Maurice, 1982) black uranium oxide minerals, hematite and pyrite are present. The only other radioactivity in the Fury and Hecla Group is caused by thorium in hematitic quartz-pebble conglomerate in the Nyeboe Formation (member 3; occurrence B, Fig. 18) (Maurice, 1982).

Dejour Mines, who staked claims over the eastern anomaly, found an extensive fault zone in the basement 100 m north of the unconformity containing a 60 cm wide subvertical quartz-hematite vein (location 70°18'N, 84°25'W). The vein, traced for 100 m yielded an average 1.6 lb/ton U_3O_8 (Northern Miner, 1980). Drilling was later carried out on their claims. This vein appears from maps to coincide with the site of the highest level of radioactivity shown in the eastern anomaly (Chandler et al., 1980, Fig. 20.2, i.e. occurrence A in Fig. 17 of this report).

From geochemical arguments Maurice (1982) and Maurice and Charbonneau (1983) considered the vein mineralization unrelated to magmatic processes. Proximity

Table 2. Chemical analyses of carbonate rocks from the Fury and Hecla Group

	(1)	(2)	(3)	(4)
SiO_2	6.5	21.3	14.2	21.9
TiO_2	0.04	0.15	0.20	0.10
Al_2O_3	1.5	2.9	2.8	1.5
Cr_2O_3	0.05	0.05	0.05	0.05
Fe_2O_3	0.0	0.0	0.5	0.0
FeO	1.6	8.7	4.1	5.4
MnO	0.10	1.16	1.33	1.12
MgO	18.9	12.6	13.7	1.91
CaO	28.0	23.3	25.9	37.2
Na_2O	0.0	0.0	0.0	0.0
K_2O	1.36	0.08	0.46	0.04
H_2OT	0.5	1.3	0.8	1.0
CO_2	40.9	28.5	34.2	28.2
P_2O_5	0.02	0.19	0.39	0.09
S	0.05	0.05	0.05	0.58
Ba	0.003	0.008	0.007	0.005
Rb	0.003	0.000	0.001	0.000
Values in ppm				
Cu	3	15	3	29
Pb	10	10	5	24
Zn	14	22	11	290
Ag	not found	"	"	"

(1) Contact metamorphosed carbonate bed, Cape Appel Member, Autridge Formation at base of sill (sample C454B).
(2) Carbonate grainstone, member 6, Dolomite Member, Agu Bay Formation (sample C461C).
(3) Pisolitic carbonate, member 6, Dolomite Member, Agu Bay Formation (sample C461D).
(4) Oolitic carbonate, Dolomite Member, Agu Bay Formation (sample L216).

to the unconformity and the simple element assemblage suggested a surficial origin. The presence of some mineralized quartz-stockwork veins (occurrence C, Fig. 18; Fig. 19) in the faulted lower redbeds of the Nyeboe Formation suggested, however, that some of the mineralization could be diagenetic, an argument supported by presence of diagenetic pore-filling hematite in the redbeds that postdates quartz cement.

Lead and zinc

Economic zinc-lead mineralization occurs at the Nanisivik Mine (Clayton and Thorpe, 1982) in carbonates of the Society Cliffs Formation of the Bylot Supergroup near Arctic Bay on the west coast of Borden Peninsula. The mineralization was deposited after karsting that followed deposition of the Victor Bay Formation carbonates, (Olson, 1977). According to Olson (1977) the mineralizing fluid was derived from late-stage dewatering of the underlying shales of the Arctic Bay Formation after burial of the karsted carbonates.

Jackson and Ianelli (1981, p. 295) correlated carbonates and underlying black shale in the Autridge Formation with the lower part of the Society Cliffs Formation and the Arctic Bay Formation, respectively. However, the writer saw no carbonates in the Autridge Formation on the north shore of Fury and Hecla Strait except for a few thin beds beneath the sill that lies south of Autridge Bay. Similarly, Blackadar, (1963, 1965, 1970) made only passing reference to ferruginous dolomite in the Autridge Formation. The only carbonate in the formation of any areal extent is an erosional remnant on Amherst Island in Fury and Hecla Strait. The writer knows, however, of no reference to karsting or mineralization in this unit.

Apart from the above carbonates in the Fury and Hecla Strait region carbonates occur at two other stratigraphic levels. Those of member 5 of the Nyeboe Formation are uniformly hematite-rich and therefore judged unlikely to carry base metal sulphides. Those of the Dolomite Member of the Agu Bay Formation appear to consist of locally developed stromatolite reefs, and lie between quartz arenite of the Sikosak Bay Formation and the overlying Black Shale Member. The reefs are evidence of organic activity that could have led to sulphate reduction. Of two samples from this member anlayzed for base metals and silver (Table 2), one contains significant amounts of zinc.

In summary, apart from the Amherst Island carbonates that ought to be examined, the carbonates of the Fury and Hecla Group are thin, show no evidence of karsting, and little evidence of base-metal mineralization.

Gold

Precambrian quartz pebble conglomerates host the largest known reserves of gold, and have provided over 60% of world production over the last 50 years (Boyle, 1979). The gold-bearing conglomerates of the Witwatersrand, R.S.A., the Jacobina Conglomerates of Brazil and the Bababudan Series of the Dharwar Group of India (Srinivasan and Sreenivas, 1972) are pyritic, Archean to Proterozoic and overlie granite-greenstone terranes.

However, one younger gold-bearing conglomerate is that of the Tarkwa Goldfield, Ghana, which is exceptional in being hematite-bearing (Boyle, 1979). It has a probable minimum age of 1.65 Ga and overlies a granite-greenstone terrane dated at about 1.9-2.1 Ga (references in Sestini, 1973).

The quartz clast conglomerate (member 3) of the Nyeboe Formation is hematitic and lies close to a basement of age and type similar to that of the Tarkwa Goldfield. For that reason 9 grab samples (Fig. 2, in pocket) of the matrix of the conglomerate, chosen from along the extent of the belt, were assayed for gold by neutron activation analysis at the X-ray Assay Labs of Toronto. Only two samples C357 at 4 ppb and CZ1 (see Fig. 2, in pocket) at 2 ppm were above the detection limit of 1 ppb.

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